東京大学理学部紀要
第二類 地質学 鉱物学 地理学 地球物理学
第十冊 第三篇

JOURNAL
OF THE
FACULTY OF SCIENCE
UNIVERSITY OF TOKYO

SECTION II
GEOLOGY, MINERALOGY, GEOGRAPHY, GEOPHYSICS

Vol. X Part III

TOKYO
Published by the University
December 10, 1957

The "JOURNAL OF THE FACULTY OF SCIENCE" is the continuation of the "JOURNAL OF THE COLLEGE OF SCIENCE" published by the University in forty-five volumes (1887-1925), and is issued in five sections:

Section I.—Mathematics, Astronomy, Physics, Chemistry
Section II.—Geology, Mineralogy, Geography, Geophysics
Section III.—Botany
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Biostratigraphie de la Série de Shizukawa (Jurassique inférieur) du Japon Septentrional

Par

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(Avec Planches I–II)

Chapitre I. Introduction

Il y a au Japon trois localités où le Jurassique inférieur affleure de façon sensible; la région de Shizukawa dans la Sud partie du plateau de Kitakami; la région de Kuruma à l'extrême Nord des Alpes japonaises, et la région de Toyora à l'extrême Ouest de Honshu. Outre ces endroits, des petits affleurements sont déjà connus au Honshu et au Shikoku; ils sont peu développés et n'ont pas fourni de fossiles indicateurs. Mais dans ces trois régions principales, les Ammonites et les Lamellibranches marins nous permettent de reconnaître les âges géologiques. Toutes ces étendues ne présentent pas la succession complète du Jurassique inférieur. La région de Shizukawa est la localité la plus classique pour le Jurassique et présente une série à peu près complète du Jurassique inférieur.

Toutefois, quelques géologues ont décrit la géologie et la paléontologie de la région, mais la stratigraphie détaillée n'est pas encore parue. J'ai abordé cette région au point de vue biostratigraphique; les résultats sont présentés ici.

Cette recherche m'a été commandé au premier par M. le Professeur T. KOBAYASHI comme le thèse de diplôme. Et je suis heureux de présenter ici une gratitude la plus biensincère à M. le Professeur T. KOBAYASHI, mon maître, qui m'a donné invariablement de critiques les plus précieuses. Je remercie M. le Professeur T. MATSUMOTO, Université de Kyushu, qui m'a informé quelques problèmes de la stratigraphie et aussi de la paléontologie d'Ammonites de ce district. Je tiens aussi à remercier particulièrement M. le

Docteur P. L. MAUBEUGE, à Nancy, qui a eu une amabilité de corriger deux fois mon manuscrit en français et surtout m'a donné quelques enseignements sur le Jurassique européen.

Historique

Cette région a été déjà plusieur fois exploitée par T. IKI (1897), M. YOKOYAMA (1904), M. KUROSAWA (1929), S. MABUTI (1933), Y. INAI (1939) et T. MATSUMOTO et A. ONO (1946). Cependant leurs comptes rendus comprirent l'ensemble de la géologie de la région, et ne présentèrent pas les détails de la succession de faune. MATSUMOTO et ONO ont essayé d'établir la biostratigraphie de l'ensemble de Jurassique, dont la partie inférieur n'a pas pu être achevée.

La région de Shizukawa est située dans la partie Sud de Plateau de Kitakami, où le Jurassique se distribue des deux côtés de l'axe anticlinale en formant deux arcs, à la partie Nord-Est de la Préfecture de Miyagi. Le Jurassique inférieur ne se développe que dans l'arc intérieur, c'est-à-dire Ouest de l'anticlinal, où l'on trouve quatre localités, notamment Chonomori, Shizukawa, Hashiura et Mizunuma, du Nord au Sud; le Jurassique inférieur se développe dans l'aire Est de chaque bassin sédimentaire qui se distribue le long de cet arc, inclinés à l'Ouest. Dans ces régions, le Jurassique inférieur s'appelle la "**Série de Shizukawa**".

Chapitre II. Stratigraphie

Ici, le Jurassique se développant dans cette région est divisé comme il suit:

5. Formation de Sodenohama 4. Formation d'Arato 3. Formation d'Aratozaki	Série de Hashiura
2. Formation de Hosoura 1. Formation de Niranohama	Série de Shizukawa

Cette subdivision a été proposée par MABUTI en 1933 grâce au faciès des roches. D'après lui, la Formation d'Aratozaki (3) a été comprise dans la Série de Shizukawa. INAI (1939) a précisé que la Formation d'Aratozaki se continuait avec celle d'Arato (4) sans aucune discord-

ance, tandis qu'elle repose sur celle de Hosoura (2) avec une faible discordance. Donc, la Formation d'Aratozaki a été exclu de la Série de Shizukawa. J'adopte ici cette division.

1. **Formation de Niranohama** (Symbole N)

Elle repose sur la couche de Saragaï avec faible discordance, dans laquelle les *Entomonotis* noriens sont très abondants. Elle est divisée en deux parties par sa faune et son faciès de haut en bas.

Nsh. Couche de schistes
Nss. Couche de grès

Nsh. *Couche de schistes*

Puissance d'environ 15 m. Alternances des schistes noirs et durs et de grès gris-noirâtre à grain fin, en lits de 35–50 cm. Ils sont entrecroisés en s'amincissant vers leurs extrémités, et continuent sur environ 10 m horizontalement. Le grès devient prédominant vers la base. Les fossiles très abondamment se trouvent, presque tous non marins, mais des indicateurs de l'âge ne sont pas encore reconnus. Cette faune est:
Polymesoda? *lunulata* (YOKOYAMA), *P.*? *elliptica* (YOK.), *Isognomon rikuzenica* (YOK.), *Gervillia trigona* YOK., *Ostrea*? sp., *Exogyra*? sp., *Trigonia senex* KOBAYASHI et MORI, *Geratrigonia hosourensis* (YOK.), *G. lata* KOB.

Ces formes sont trouvés très abondamment dans les schistes ou les grès, entre lesquels les Trigonidés se trouvent dans des assises assez étroitement délimitées. *Trigonia* et *Geratrigonia* sont très caractéristiques, et la "Zone à *Geratrigonia hosourensis*" est incontestablement reconnue.

Il est aisément distinguable que cette couche a été déposée dans un milieu deltaïque, quand on remarque leur stratification entrecroisée. Puisqu'elle repose sur la formation norienne de Saragai et qu'elle se poursuit par des couches de grès qui founissent *Yebisites* probablement de l'âge héttangien, elle doit être anté-hettangien et post-norien. Mais sa faune de Lamellibranches a une affinité plus liasique que rhétienne, et elle ne doit pas être du Rhétien.
Affleurement typique:—Côte Sud-Ouest de Niranohama, Utazu, Préfecture de Miyagi.

Nss. *Couche de grès*

Puissance d'environ 20 m. Grès noirâtre à grain moyen et gros, souvent riche en grains du quartz, devient fragile et brun à l'affleurement, et est barré à mi-épaisseur par un grès conglomératique ou par un conglomérat qui montrent une disposition très irrégulière; les galets remaniés sont des schistes noirs et des grès à grains fin originaires sûrement des couches des schistes susjacents, avec aussi des galets arrondis: ces conglomérats sont entrecroisés dans des grès, et intercalés dans des assises houillères très minces. A la partie supérieure, des grès massifs sont prédominants. Tous ces grès supérieur et inférieur ont fourni des Trigonidés si abondamment qu'ils forment une lumachelle. On relève;
Vaugonia niranohamensis KOBAYASHI et MORI, *V. yokoyamai* K. et M., *V. namigashira* K. et M., *Orthotrigonia midareta* K. et M., *O. corrugata* K. et M., *Yebisites onoderai* MATSUMOTO.

Cette couche correspond à l'Hettangien moyen, parce qu'elle a fourni *Yebisites** dans le grès supérieur. La grande abondance de Trigonidés est remarquable. Les assises à Trigonidés sont peu épaisses et continuent jusqu'à quelques kilomètres du Nord au Sud, et représentent l'action de l'extraction.
Affleurement typique:—Côte Sud-Ouest de Niranohama. Les assises à Trigonidés se trouvent à l'Est de Hosoura vers le Nord, et sur la petite île de Gongen vers le Sud.

2. Formation de Hosoura (Symbole H)

Puisque cette formation a fourni des Ammonites Jurassiques inférieures exclusivement à la Nord partie du Japon, elle nous est bien familière. Cependant, ces Ammonites ont été mal identifiées et par conséquent, leurs couches d'origine ont été attribuées à un âge faux. De plus, parce qu'elles ne se trouvent pas dans des niveaux nettement distinguables, on ne peut pas constater leur ordre de succession. J'ai exploré cette couche et propose ici une classification zonale.

Au point de vue lithologique, la formation doit être divisée entre deux parties; inférieure, schistes gréseux: supérieure schistes

* *Yebisites*, proposé par MATSUMOTO en 1956, très proche d'*Alsatites*, et probablement Hettangien moyen ou supérieur.

massifs. La partie inférieure ne fournit pas des fossiles si abondamment, mais on peut constater dans le schiste massif les zones à Ammonites comme citées en bas.

Hh. Zone à *Hammatoceras*
Hl. Zone à *Leioceras* (?)
Ha. Zone à *Arnioceras*
Hi. Couche de schistes gréseux, non fossilifére.

Hi. *Couche de schistes gréseux*

Puissance variable; au village de Hosoura, on compte presque 50 m de grès noirs apparemment hétérogènes par le changement fréquent du calibre des grains. Vers la base, la stratification entrecroisée se développe, et des bois silicifiés ont été fréquemment trouvés. Elle a fourni: *Vaugonia* sp., *Pecten*? sp.

Ha-h. *Couche de schistes gréseux à Ammonites*

Cette couche a fourni assez abondamment des fossiles marins, surtout des Ammonites et des Belemnites. En dehors de ces fossiles, j'ai trouvé un os de Vertébré indéterminé, et beaucoup de Lamellibranches et de Gastéropodes. Puissance d'ensemble de 100 m±: consistant en des schistes gréseux barrés de parties plus arénacées, et par des lentilles ou des assises minces de grès, et de conglomérats; vers la parite la plus supérieure, les gros nodules de grès calcaires deviennent abondants. Les parties fournissant les fossiles ont une tendance plus massive que les autres.

Ha. *Zone à Arnioceras*: Puissance d'environ 10 m; elle est connue exclusivement par les blocs isolés grâce à des failles plus ou moins importants; ses limites supérieure et inférieure ne sont pas encore reconnues. Sur la côte de Gongen (partie la plus Sud de cette région) on ne pouvait pas trouver les fossiles caractéristiques de cette zone, tandis que l'on peut tracer la succession de Nss à Hl. Mais cette absence de ces fossiles indicateurs, *Arnioceras*, ne semble pas indiquer un manque des couches correspondantes de cette zone, mais traduire un faciès plus pélagique où les fossiles nécroplanctoniques ne se sont pas déposés.

Cette zone repose sur Hl sans aucune discordance. Elle se compose de schistes très gréseux, souvent passant au grès en général irrégulièrement interstratifié dans les schistes. Elle a fourni assez

abondamment *Arnioceras yokoyamai* (MATSUMOTO).

Comme cité plus haut, on ne peut pas reconnaître la relation de cette zone avec les assises superposées. Mais elle se comprend une faune indépendante, et n'a jamais fourni des Ammonites des autres zones; c'est une preuve de ce qu'elle compose une zone indépendante.

Affleurement typique:—Nakazai, Utazu, Préfecture de Miyagi.

Hl. *Zone à Leioceras* (?): Puissance d'environ 25 m. Elle se compose de lits de schistes noir-verdâtres, très massifs, et a fourni abondamment les fossiles de la Formation de Hosoura, surtout des Ammonites, puis secondairement des Lamellibranches et des Gastéropodes. Vers la base, elle devient plus arénacée, et enfin passe au grès à gros grain ou quelquefois à des conglomérats, qui comprennent des galets arrondis ou ceux d'argiles noires et charbonneuses, remaniés; souvent, apparaissent des assises de grès gris de 5 cm d'épaisseur, fournissant des Lamellibranches. *Leioceras* (?) *ikianum* (YOKOYAMA), *Hyperlioceras* sp., *Holcophylloceras* cf. *ultramontanum* NEUMAYR, *H.* sp., *Harpoceras* s. str. *okadai* (YOK.), *Tmetoceras recticostatum* SATO, Belemnites gen. et sp. indet., *Vaugonia kodaijimensis* KOB. et MORI, *V. niranohamensis* K. & M., *Inoceramus* spp., *Pinna* sp.

Les Lamellibranches se trouvent dans les assises du grès qui sont intercalées dans les schistes massifs, en formant un petit banc, mais ils ne se trouvent que rarement dans les schistes euxmêmes.

Hh. *Zone à Hammatoceras*: Puissance d'environ 70 m. Je peux reconnaître les deux sous-zones à Ammonites dans cette zone, dont les faunes sont composées d'éléments exactement identiques. Toutefois, je ne les diviserai pas en deux parties, employant une seule zone.

Le faciès de roche suggère la disposition au fond d'une baie entourée par des barrières sous-marines. Elle se compose de schistes noirs et gréseux, barrés de nombreuses assises minces de grès gris, et est souvent gréseuse sporadiquement. La partie la plus supérieure, de 20 m d'épaisseur, renferme très abondamment des nodules elliptiques de grès calcaires, dont le diamètre atteint souvent un mètre et qui sont bien comprimés. Quelquefois elle montre des lentilles peu épaisses de grès calcaire, qui s'amincissent vers leurs extrémités, et enfin disparaissent. Elle a fourni: *Hammatoceras*

kitakamiense (SHIMIZU), *H. subtile* SATO, *H. tuberculata* SATO, *H. hosourense* SATO, *H. chibai* (YOK.), *Hyperlioceras* sp., *Tmetoceras recticostatum* SATO, *Leioceras* (?) sp., *Kallilytoceras* sp., *Phylloceras* s. l. sp., Belemnites gen. et sp. indet., Trigonidé gen. et sp. indet., *Pinna* sp., *Inoceramus* spp., Gastéropode gen. et sp. indet.

Les fossiles ne se trouvent pas dans un niveau limité, mais uniformément sur toute l'épaisseur de la zone sans concentration remarquable.

Les zones citées plus haut ont leur âge exactement précisé par leur faune.

Zone à *Arnioceras*..................Sinémurien inférieur
Zone à *Leioceras* (?) ....Aalénien inf. et Toarcien sup.
Zone à *Hammatoceras* ....Aalénien

La lacune du Lias moyen et supérieur doit être reconnue. Cela se manifeste par le conglomérat avec galets remaniés entre les zones à *Arnioceras* et à *Leioceras* (?), bien que le conglomérat ne se trouve pas toujours, et que les limites de deux zones ne peuvent pas toujours être constatées exactement.

La Formation de Hosoura est surmontée par la Formation d'Aratozaki avec faible discordance, visible à Akaiwazaki, Sud-Ouest du village de Hosoura. Celle-ci se compose de grès brun-rougeâtre ou gris-bleuâtre, et très massif, et a fourni les Lamellibranches marins contenant les Trigonidés peut-être du Bajocien.

Sommaire

Donc, la Série de Shizukawa est divisée comme il suit, en représentant les zones par les fossiles.

Hh.	Zone à *Hammatoceras*	Formation de Hosoura
Hl.	Zone à *Leioceras* (?)	
Ha.	Zone à *Arnioceras*	
Hi.	Zone de schistes gréseux	
Ass.	Zone à *Yebisites*	Formation de Niranohama
Nsh.	Zone à *Geratrigonia*	

Cette division est marquée naturellement suivant des *Unité de Temps et de Faciès*. La chronologie absolue doit être accomplie universellement, mais les présences disharmonieuses de faune dans une

couche entre les régions européenne et asiatique ont été constatées après une analyse minutieuse. Donc, les géologues japonais ont essayé d'établir une échelle appliquable à l'Asie orientale, ou au moins au Japon. De mon côté, je constate que la division du Jurassique à Shizukawa est exactement harmonieuse au point de vue du faciès et de la faune. Cependant, on ne peut pas reconnaître la "Zone" au sens d'Oppel: "Une zone est représentée par la durée d'une espèce caractéristique"; dans cette région, je n'ai pas pu saisir de subdivision plus détailée que des présences de genres. De plus, c'est grâce à une association de quelques genres que l'on peut distinguer chaque zone dans les couches continues, excepté des cas très spéciaux. C'est une grande différence entre le Japon et l'Europe.

3. Données sommaires sur le Jurassique inférieur du Japon.

Au Japon, le Jurassique inférieur (y compris celui del'âge douteux) affleure, du Nord au Sud, à Kitakami, à Iwamuro (Préfecture de Gumma), à Kuruma, à Yamaoku (Préfecture d'Okayama), et à Nagato; au dehors de ces localités, la couche très épaisse mais d'âge incertain s'étend à la partie externe du Japon SO. Parmi ces régions, les fossiles utilisables pour une corrélation se trouvent à Kitakami, à Kuruma et à Nagato; les autres n'ont fourni que des fossiles végétaux et Lamellibranches qui suggèrent un âge rhéto-liasique. J'ai tenté une corrélation avec le Jurassique inférieur de ces trois régions du Japon.

3a. *Partie Sud du Plateau de Kitakami*

Le Jurassique inférieur se devéloppant dans la partie Sud du Plateau de Kitakamai y forme les deux arcs parallèles, concaves à l'Ouest. Dans l'arc externe il n'y a pas des sédiments exactement du Jurassique inférieur. Tandis que la Série de Karakuwa dans la région de Karakuwa, a été condisérée comme un correspondant de la Série de Shizukawa, j'ai trouvé dans cette série un *Stephanoceras* qui indique l'âge bajocien. Au contraire, dans l'arc interne le Jurassique inférieur se développe, aux régions de Chonomori, de Shizukawa, de Hashiura et de Mizunuma, du Nord au Sud. Cependant dans la région de Chonomori les grès noirs qui reposent sur le

Text-fig. 1. Répartition du Jurassique inférieur du Japon. S. Sud Partie du Plateau de Kitakami, (Série de Shizukawa), I. Iwamuro (Formation d'Iwamuro); K. Kuruma (Série de Kuruma); Y. Yamaoku (Formation de Yamaoku); T. Nagato (Série de Toyora).

Norien à *Entomonotis* sont reconnus comme du Jurassique inférieur, mais on n'y trouve pas de fossiles. Les dépôts correspondants à la Formation de Niranohama sont reconnus dans toutes les autres régions, d'où proviennent *Geratrigonia hosourensis, Polymesoda, Gervillia,*

Text-fig. 2. Répartition du Jurassique dans la Sud partie du Plateau de Kitakami. A: Série de Shizukawa; B: Série de Karakuwa; C: Série de Hashiura (inclus la Série de Jusanhama); D: Série de Shishiori 1: Karakuwa; 2: Shishiori; 3: Kesennuma; 4: Chonomori; 5: Aratozaki; 6: Hosoura; 7: Shizukawa; 8: Hashiura: 9: Magenosu; 10: Mizunuma; 11: Ishinomaki; 12: Kodaijima; 13: Oginohama.

Isognomon et d'autres Lamellibranches non marins. Au dessus de cette couche, reposent les grès à *Vaugonia* dans la région de Shizukawa et de Hashiura, mais ils ne sont pas reconnus à Mizunuma. Une association de *Vaugonia* et de *Yebisites onoderai* a été constatée à Shizukawa; de plus *Arnioceras* cf. *geometricus* qui a été rapporté par MORI dans la région de Hashiura doit être considéré comme une affinité de *Yebisites* selon mon observation. *Yebisites* a de très grandes affinités avec *Alsatites*, et sa présence indique un niveau très voisin de celui d'*Alsatites*, d'après MATSUMOTO (1956).

Comme dit plus haut, les divisions chronologiques de ces régions semblent assez harmonieuses au point de vue paléontologique et aussi lithologique.

Ce que l'on doit remarquer en particulier est les faits suivants.
a) La Formation de Niranohama, ou son équivalent, se développe bien dans trois régions, et fournit des faunes communes. Cependant, à Mizunuma les couches à *Vaugonia* sont à peine reconnues.
b) La Formation de Hosoura n'est bien développe qu'à Shizukawa; elle y a 200 m d'épaisseur, mais vers le Sud, amincie, elle a seulement 10 m à Hashiura, où se trouvent des Ammonites très fragmentaires; à Mizunuma elle n'a pas été reconnue sur la présence d'Ammonites. Ce fait suggère que la mer de cette période diminua, vers le Nord, et que la région de Shizukawa correspond au fond de la baie.

La Formation d'Atagoyama de la région de Chonomori n'a pas fourni de fossiles, mais je la traiterai comme un correspondant de la Formation de Niranohama, jugée ainsi par son faciès et sa relation avec la Formation de Saragai.

La Formation de Kodaijima de la presqu'île d'Ojika et la Formation de Kosaba ont fourni Trigonidés, notamment *T. sumiyagura*, qui se trouve aussi dans la Formation d'Aratozaki de la région de Shizukawa. Donc, les deux Formations, qui ont été considérées comme les représentants de la Formation de Niranohama dans cette région correspondant en réalité à la Formation d'Aratozaki.

3b. *Groupe de Kuruma*

Au Sud de la région de Shizukawa, le Jurassique inférieur a été reconnu dans la région d'Iwamuro et de Kuruma. Les fossiles végétaux y ont été abondamment trouvés; ils se composent des

flores rhéto-liasiques. Dans ces régions, les Lamellibranches très riches sont connus récemment, qui indiquent la déposition du fond de la baie ouverte ou demi-renfermée. Le groupe d'Iwamuro n'a pas fourni de fossiles indicateurs, mais sa faune de Lamellibranches est tout à fait identique avec celle du groupe de Kuruma. En practice, il est traité comme un équivalent du groupe de Kuruma. Le groupe de Kuruma nous a fourni très heureusement une faunule d'Ammonites dans la Formation de Teradani et d'Otakidani. Cette petite faunule d'Ammonites comprend des Ammonites des genres: *Amaltheus, Canavaria* et *Deroceras*, qui indiquent le Pliensbachien supérieur. Cet étage manque complètement dans le Groupe de Shizukawa, et semble correspondre à la lacune entre la zone à *Arnioceras* et celle à *Leioceras* (?). Une telle existence d'une faune très indépendante suggère que les sédiments Jurassiques du Japon ont été déposés dans un bassin indépendant à chaque étage. La Formation d'Otakidani correspond peut-être à un membre de Hl, jugé par la présence de *Grammoceras*, mais une corrélation plus précise est impossible, parce que ce genre n'est pas trouvé à Shizukawa.

Table 1. Corrélation des coupes principaux

<table>
<tr><th></th><th>Nagato</th><th>Kuruma</th></tr>
<tr><td rowspan="3">Form. Utano</td><td>Partie supérieure</td><td></td></tr>
<tr><td>Zone à Hammatoceras Uh
Zone à Haugia ? Ub</td><td>Formation de Mizukamidani
?</td></tr>
<tr><td>Zone à Pseudolioceras Up</td><td>Formation d'Otakidani</td></tr>
<tr><td rowspan="2">F. Nishi-nakayama</td><td>Zone à Dactylioceras Ni
Zone à Hildoceras Nh
Zone à Grammoceras Ng</td><td>Formation de Shinatani</td></tr>
<tr><td>Zone à Fontanelliceras Nf</td><td>Formation de Teradani</td></tr>
<tr><td rowspan="2">F. Higashi-nagano</td><td>Zone à Arietites</td><td>Formation de Negoya</td></tr>
<tr><td>Zone à Harpophylloceras</td><td>?
Formation de Kitamatadani
?
Formation de Jogodani</td></tr>
</table>

3c. *Groupe de Toyora*

Dans le Japon du SO, on a reconnu le Jurassique inférieur à Yamaoku et à Nagato; la couche de Yamaoku n'a fourni que des fossils végétaux semblablement correspondant à la flore de Kuruma, c'est-à-dire rhéto-liasique, et des Lamellibranches. Contrairement à ce développement médiocre à Yamaoku, on peut trouver le Jurassique inférieur bien représenté à Nagato, qui a donné le nom du Groupe (Série) de Toyora. Il offre une belle succession des faunes d'Ammonites, qui indique une période allant sûrement de l'Hettangien à l'Alénien. Mais il est très curieux que l'on ne puisse pas recueillir les Ammonites communes avec les faunes de Shizukawa, sauf *Harpoceras okadai*. De plus, le Lias moyen, qui est complètement absent de la région de Shizukawa, est bien développé ici. Au contraire, le Dogger le plus inférieur (Aalénien) est très mal développé à Nagato.

La corrélation entre les trois régions est figurée dans le tableau en bas.

du Jurassique inférieur du Japon.

	Shizukawa	Etage standard
Formation Hosoura	Zone à *Hammatoceras* Hh	Aalénien
	Zone à *Leioceras* ? Hl	Toarcien sup.
		Toarcien moy. et inf.
		Pliensbachien sup.
	Zone à *Arnioceras* Ha Schistes non fossilif. Hi	Sinémurien
F. Niranohama	Zone à *Yebisites* Hss Zone à *Geratrigonia* Nsh	Hettangien

Il faut noter que les faunes caractéristiques à chaque étage se développent dans des régions différentes. La faune du Pliensbachien et du Toarcien inférieur et moyen qui manque complètement dans la région de Shizukawa est bien connue à Nagato. Au contraire, les faunes sinémurienne, toarcienne supérieure et aalénienne sont mal développées à Nagato. (Il faut négliger le Groupe de Kuruma puisque l'on a trop peu de connaissances sur la stratigraphie de celui-ci jusqu'à présent.)

En premier lieu, il est probablement correct que les deux zones, Up, Ub, caractérisées par *Haugia*? et *Pseudolioceras* correspondent à la zone à *Leioceras* (?) du Groupe de Shizukawa, puisque *Haugia* et *Pseudolioceras* se trouvent quelquefois en association avec *Leioceras* en l'Europe, et que la zone à *Leioceras* (?) se poursuit dans la zone à *Hammatoceras* à Shizukawa.

Leioceras (?) suggère un genre nouveau, mais semble très proche de *Leioceras* typique. Je pense qu'il est originaire de *Leioceras* par migration et ségrégation géographique. Un seul échantillon a été trouvé dans le Groupe de Toyora et il n'est pas bien conservé. *Harpoceras* s. str. *okadai* est trouvé à la zone de Ng-Nh à Nagato, qui est considérée comme du Toarcien moyen, et aussi à la zone à *Leioceras* (?) de Shizukawa, qui est un dépôt du Toarcien supérieur, mais sa coexistence avec *Leioceras* n'est pas contradictoire avec l'échelle de l'Europe.

La lacune biostratigraphique du Pliensbachien supérieur au Toarcien moyen dans le Groupe de Shizukawa est très remarquable. J'ai trouvé un conglomérat avec des galets remaniés à la base de la zone à *Leioceras* (?), mais ceci très localement, et sans continuation horizontale. Les galets remaniés dans ce conglomérat suggèrent l'existence d'un fond de baie pour le depôt, et indiquent une erosion sous-marine à cette époque, à mon avis. Cependant, comme on ne peut pas saisir la relation des deux zones au Nord de cette région, ceci laisse le problème irrésolu.

Dans la zone externe du Japon SO, les couches qui sont signalees comme du Jurassique inférieur ont été observées. Mais elles n'ont pas été explorées au point de vue biostratigraphique, et n'ont pas fourni de fossiles indicateurs, je ne pouvais pas essayer leur corrélation.

4. Corrélation avec les Régions circumpacifiques

La mer du Jurassique inférieur s'est étendue plus ou moins dans la région circumpacifique. Mais dans chaque localité, le Jurassique inférieur ne continue pas de l'Hettangien à l'Aalenien, on peut toujours reconnaître seulement un étage mieux développé. Un tel étage est caractérisé par sa faune d'Ammonites. Je ne puis pas examiner les Ammonites de chaque région, dont quelques-unes doivent être réexaminées au point de vue paléontologique; ici, j'essaierai les corrélations possibles basées sur les Ammonites.

4a. *Transbaikal*

Le long du fleuve Amur, le Jurassique est distribué sporadiquement, et à l'Est d'une partie des Montagnes de Transbaikal (entre les fleuves d'Onon et de Gashimur), la succession des couches (qui sont marines) est reconnue. KHUDIAEV a rapporté l'ordre de cette succession, et clarifié la faune qui est assez riche en Ammonites liasiques. La faune est composée de *Harpoceras* et ses formes affines à la partie supérieure de cette série. Le Jurassique marin est connu dans la région de la Wilui; mais la faune de la région est caractérisée par des éléments boréaux. Au contraire, celle du Transbaikal est sûrement de caractère Pacifique. Le long du fleuve Amur, on signalait un géosynclinal assez long comme " Géosynclinal d'Amur ", qui s'est continué par le Pacifiqué Nord, mais non par la Mer Arctique, comme le prouve la faune en provenant.

4b. *L'Ussurilande*

Le Lias supérieur a été signalé près du fleuve de Peschtschanka, mais il fournit seulement les Lamellibranches marins. Je ne puis pas corréller avec notre région.

4c. *Hongkong*

La Formation de Tolo Channel a fourni *Hongkongites hongkongensis* (GRABAU) (1923, p. 199, Pl. I, Figs. A, B) et *H.* sp. cf. *angulatoides* QUENSTEDT, (Ibid., Fig. C) et sa variete qui sont proches de *Schlotheimia* de l'Hettangien européen. L'Hettangien est reconnu dans le

Japon du Nord, c'est-à-dire la Formation de Niranohama, fournissant *Yebisites*. Les Schlotheimidés sont cités dans l'île deRotti, la Sonde mineure, et la faune de l'Hettangien a été reconnue dans le Pacifique Sud. La citation de *Schlotheimia*, par YOKOYAMA, doit être abandonnée. Le spécimen illustré par lui n'est pas obligatoirement *Schlotheimia*, car il est trop mal conservé pour l'identifier.

4d. *L'île de Mindoro, Philippines*

On avait constaté que le Jurassique n'existe pas dans les Philippines; mais DE VILLA a cité une faune jurassique près de Mansalay, l'île de Mindoro, qui est identifiée avec beaucoup de doutes. HAYASAKA a réexaminé la faune et constaté les genres d'Ammonites suivants: *Peltoceras*, *Oppelia*, *Arietites*, *Macrocephalites*, *Streblites*, *Perisphinctes*. *Arietites* provient en général du Sinémurien inférieur; même si ce genre représente une affinité d'Arietitidés, il se trouve à la même localité avec les autres: c'est très enigmatique. Si l'identification d'*Arietites* est correcte, cet horizon, ou au moins une partie de cet horizon, est synchronisable avec la zone à *Arnioceras* de Kitakami.

4e. *L'Indochine et le Thaïlande*

Au Quangnam, l'Hettangien a été constate par l'existence de *Psiloceras longipontinum* dans le Haut Laos; et au Tonkin et au Nord du Yunnan oriental, les calcaires à Brachiopodes sont connus mais des Ammonites n'ont pas été fournies. Au Huu-Nien du Bas Laos, l'Hettangien est connu avec *Psiloceras longipontinum*: cette zone de l'Hettangien est un peu plus ancienne que la zone à *Yebisites*, représentant la base du Lias. Vers le Sud, en Cochinchine et au Cambodge oriental, le Toarcien a été précisé d'après *Hildoceras lantenoisi** (MANSUY, 1914, p. 38, Pl. IV, figs. 4a-e) et *Hildoceras* cf. *quadratum*. Comme celle-ci est un *Pseudogrammoceras* et celui-là n'est pas *Hildoceras*, cette couche semble correspondre à notre Ng-Nh à Nagato.

Dans la région de Mae Sot du Thaïlande, SRESTHAPUTRA et les

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* Il appartient peut-être à une forme de Harpocerataceae, sutout à un de ses descendants, par exemple *Fuciniceras* ou ses affinités.

autres auteurs ont rapporté du calcaire de Kamawkala une faune bajocienne, qui comprend *Erycites* sp., *Tmetoceras* sp. et *Ludwigia* sp., identifiés par IMLAY. La découverte de *Tmetoceras* est particulièrement importante pour la corrélation; les zones à *Leioceras* (?) et à *Hammatoceras* de Kitakami ont abondamment fourni *Tmetoceras recticostatum*; les deux sont complètement synchroniques.

4f. *L'Indonésie*

Beaucoup des petites îles de l'Indonésie ont fourni des fossiles marins du Lias. Cependant, excepté quelques rares exemplaires, l'ordre zonal de leur provenance n'a pas été constaté de telle sorte que l'on puisse établir l'échelle stratigraphique pour ces régions. Naturellement, c'est très difficile, mais très désirable. Habituellement on arrange les niveaux de bas en haut grâce à leurs fossiles caractéristiques quand on ne peut pas connaître leurs relations stratigraphiques. C'est raisonable au point de vue biostratigraphique quand on veut comparer de façon assez large. Cependant, ce n'est pas suffisant quand on veut reconnaître la relation exacte entre les couches et leur faune de fossiles. Car, il est possible que le même genre provienne d'une zone tout à fait différente de l'autre côté de la terre. *Schlotheimia* cf. *marmorea* (KRUMBECK, 1922, p. 193) provient de l'île de Rotti est une forme qui, sûrement, represente la zone à *angulatus* de l'Europe, et correspond au moins à la base de la zone à *Yebisites* du Japon. Le Sinémurien supérieur précisé par *Arnioceras* et ses formes affines, est reconnu aux îles de Babber, Rotti, Timor, Jambdena, Celèbes et Buton. L'île de Rotti, surtout, a fourni beaucoup d'espèces de ce genre.

Arnioceras mendax (JAWORSKI, 1933, p. 257) île de Rotti, zone à *bucklandi*.
A. cf. *fortunatum* (JAWORSKI, 1933, p. 258, pl. CI, Figs. 1a-c) île de Rotti, Sinémurien inférieur.
A. rotticus (ROTHPLETZ, 1892, p. 97, pl. xiv, fig. 2; KRUMBECK, 1922, p. 189, Pl. XVII, Figs. 12a-c) intime à *bucklandicostaries* QU., île de Rotti, zone à *bucklandi*.
A. geometricus (ROTHPLETZ, 1892, p. 100, pl. xii, fig. 2; KRUMBECK, 1922, p. 184) île de Rotti, Timor, zone à *bucklandi*.
A. cf. *semilaeve* (JAWORSKI, 1933, p. 260; WANNER et JAWORSKI, 1931, p. 201, Pl. CIX, Figs. 3a, b) île de Célèbes, recueilli dans le débris de la Rivière Balingara.
A. sp. cf. *arnouldi* (JAWORSKI, 1933) île de Jambdena, zone à *bucklandi*.

Il est très naturel que le Lias japonais ait une affinité très intime avec celui du Pacifique Sud, au point de vue non seulement stratigraphique mais aussi faunal. L'abondance des Phylloceratidés et des Lytoceratidés est une evidence de cette affinité.

A. cf. *fortunatum* est très proche de notre *A. yokoyamai*, jugé par la figure de JAWORSKI. *Asteroceras sparissicostatum* (WANNER 1931, Pl. XIX, Fig. 1) de l'île de Jambdena est trouvé au Lotharingien. Les schistes bitumineux à *Harpoceras radians* de Rotti sont considérés comme du Toarcien, mais il n'y a pas de zone correspondant exactement à celle-là dans notre région, car il s'agit peut-être de *Grammoceras*.

Leioceras et ses formes affines n'ont pas été trouvés dans la région indonésienne, mais *Harpoceras* et ses proches parents qui se trouvent en association avec *Leioceras* dans la zone à *Leioceras* (?) du Plateau de Kitakami ont été cités assez abondamment. *Harpoceras* s. str. n'y a pas été rapporté. Les *Harpoceras* se trouvent tout dans le Toarcien en Europe (tandis qu'il y a déjà une forme parente dans la zone à *spinatum*, comme *Argutarpites* BUCKMAN), et les formes citées pour ce genre à Rotti suggèrent fortement une affinité avec notre *Leioceras* (?). Je pense que les deux niveaux sont représentés avec cet *Harpoceras* et que notre *Leioceras* (?) est presque synchronique.

Plusieurs formes de l'île de Misol décrites par SOERGEL (1913) comme "*Harpoceras*" comprennent *Pleydellia*, *Grammoceras*, *Haugia* et *Brodiceras*, mais *Harpoceras* s. str. n'est pas reconnu. Cette association semble un peu plus ancienne que la zone à *Leioceras* (?) de notre région. *Harpoceras landui* (BOEHM, 1908, p. 323, Pl. XII, Figs. 1a-c, Text-fig. 3) qui se trouve à l'île de Rotti représente une forme du Toarcien.

Hammatoceras moluccanum (CLOOS, 1916, p. 5, et 11; KRUIZINGA, 1926, Pl. 2, Fig. 1-3) et ses variétés sont reconnus dans les îles de Sula, de Misol, et de Sumba. Ils sont tout à fait proches de notre espèce; et ils représentent sûrement l'âge aalénien. *Hammatoceras* cf. *lotharingicum* (JAWORSKI, 1920, p. 199, Pl. I, Figs. 5, 5a) est proche de *H. sieboldi*, qui se trouve dans les zones à *opalinum-murchisonae*. Ceci suggère fortement que les deux zones sont synchroniques (tandis que se trouvent assocciés des *Grammoceras* et *Harpoceras arietiformis*). *Hammatoceras klimakomphalum* est cité à l'île de Babber. *Tmetoceras* qui provient en association avec *Hammatoceras* dans la

région de Shizukawa n'a pas été encore reconnu dans celle du Pacifique Sud. Phylloceratidés et Lytoceratidés sont abondamment représentés dans l'Indonésie, et prouvent la connexion directe entre deux régions par la mer. *Hammatoceras* a été très caractéristique aussi dans la zone du Pacifique. Il indique les zones à *opalinum* ou *murchisonae* dans cette région, ce qui est très utile pour la corrélation.

4g. *Nouvelle Guinée, Nouvelle Calédonie et Nouvelle Zélande*

Psiloceras et *Schlotheimia* sont rapportés dans l'Araturan de la Nouvelle Zélande et la Nouvelle Calédonie; ces couches fournissant des Ammonites sont un peu plus anciennes que la zones à *Yebisites* de notre région. *Arnioceras* sp. (AVIAS, 1953, p. 153, Pl. XX, Figs. 12a, b; Text-fig. 96) de la Nouvelle Calédonie est un élément rare du Sinémurien de cette région. De plus, aucun céphalopode fossile n'a pas été trouvé comme provenant du Lias supérieur, tandis que cet âge serait représenté par les Laméllibranches. Les géologues australiens datent le Lias supérieur par les Brachiopodes et par les Lamellibranches. Des faunes d'Ammonites sont très mal developpées, de telle sorte que seulement *Dactylioceras* a été fourni dans l'Ururvan.

4h. *L'Alaska*

Dans l'Alaska, Le Lias a été précisé pas les Ammonites assez riches. Aux environs de la presqu'île d'Alaska, les faunes du Sinémurien, du Pliensbachien et du Toarcien ont été reconnues, qui n'ont pas été décrites, et remarquablement proche du Japon septentrional et central. A la baie de Puale et à la baie d'Alinchak de la presqu'île d'Alaska, le Sinémurien a fourni *Coroniceras* et *Arnioceras*. *Coroniceras* a été aussi trouvé dans le tuff de la presqu'île de Kenai, au Cook Inlet, ce qui indique au moins du Pliensbachien. La formation de Talkeetna, qui a fourni *Schlotheimia*, *Deroceras*, *Xipheroceras* a été considérée comme du Pliensbachien, mais cette faune n'a pas été décrite. La coexistence de *Schlotheimia*, représentant habituellement l'Hettangien, avec *Deroceras* et *Xipheroceras* est très contradictoire comme IMLAY l'a considéré. Plus Nord, dans la région de Brooks, Alaska septentrional, le "Kingak shale" a fourni *Arietites* cf. *A. bucklandi* dans une carotte de forage "Avak 1".

Le Lias supérieur a fourni une faune tout à fait riche sur la presqu'île d'Alaska et à Cook Inlet. A la baie de Wide de la presqu'île, la Formation de Kalagvik est caractérisée par *Erycites howelli* (l'original de WHITE est *Lillia*; WHITE, 1889, p. 68, Pl. XII, Figs. 1, 2, Pl. XIV, Figs. 1-3), *E. kialagvikensis* (d'après HAUG, proche de *Grammoceras toarcense*, WHITE, 1889, p. 69, Pl. XIII, Fig. 7), *Pseudolioceras whiteavesi* (WHITE, 1889, p. 69, Pl. XIII, Figs. 1-5), *Tmetoceras*, *Hammatoceras*, et *Sonninia* (qui est un élément de la zone à *discites*, et donc, douteux), qui supporte la corrélation avec la zone à *murchisonae* en Europe d'après IMLAY. Cette association de *Hammatoceras* et de *Tmetoceras* a été reconnue aussi dans notre région; les deux niveaux sont donc exactement synchroniques. Dans le cas de la Formation de Hosoura, un niveau supérieur de la zone à *Hammatoceras* n'est pas constaté, au contraire de la Formation de Kialagvik, où la zone à *sowerbyi* a été précisée. Cette association a été aussi constatée pour la Formation de Tuxedoni de la baie de Tuxedoni, qui fournit Phylloceratidés, Lytoceratidés, Sonninidés et *Harpoceras* (?).

Récemment IMLAY a décrit la faune du Mollusque dans la région septentrionale d'Alaska. Les Ammonites que IMLAY a précisé sont tout à fait ressemblant à nos formes du Lias supérieur. C'est étonnant que les Ammonites toarciennes et aaléniennes se distribuent non seulement sur la côte Sud d'Alaska, mais aussi dans la région septentrionale, qui est confronté la mer Arctique, plus nord que la cercle Arctique. Outre *Arietites* déjà cité, il y a 4 assemblages caractéristiques, qui représentent les zones ou niveaux indépendants dans la soi-disant "Kingak Shale". *Pseudolioceras* cf. *Ps. lythense* (IMLAY, 1955, p. 89, Pl. 12, Fig. 20), *Pseudolioceras* cf. *compactile* (IMLAY, 1955, p. 89, Pl. 12, Figs. 17, 18, 21) qui ont été recueillis dans la vallée d'Ignek, considérés comme du Toarcien supérieur ont une ressemblance remarquable avec les formes que j'ai cité ici comme *Hyperlioceras*. Notre *Hyperlioceras* est exactement associés avec les autres formes tels que *Tmetoceras* et *Hammatoceras*. *Tmetoceras* sp. et *Erycites howelli* sont trouvés aussi dans le Bajocien inférieur en association avec *Pseudolioceras*, dans cette région d'Alaska septentrional. On constaterai une affinité très intime entre les deux régions du Japon septentrional et d'Alaska, avec les faunes les plus proches du Toarcien supérieur et de l'Aalénien.

L'île de Prince Patrick, dans la mer Arctique, a aussi fourni

une faune comprennant *Ludwigella* et *Harpoceras*. Celui-là a été décrit comme *Harpoceras* cf. *exaratum*, qui est très ressemblant à notre *Harpoceras okadai*.

Donc, la mer du Lias supérieur a été en connexion très large avec non seulement le Pacifique mais aussi avec la mer boréale par la passage située dans la partie la plus nord du Pacifique actuel.

4i. *Le Canada*

Le Lias démontré par l'existence d'Ammonites indicatrices est connu dans les régions suivantes au Canada; la Colombie britanique (île de Reine Charlotte, île de Vancouver, le district autour de Hazelton, le district du lac de Harrison, une partie SO de l'Alberta), le district du lac de Laberge, Yukon, île du Prince Patrick sur la mer arctique.

Dans le district du lac de Tyaughton, en Colombie britanique, l'Hettangien a été précisé par la présence de *Psiloceras canadense*, et *Scamnoceras* cf. *acuticostata*. Il en est de même du fleuve Fraser en Colombie britanique. Il n'y a pas d'horizons exactement corrélatifs avec ces zones dans la série de Shizukawa, mais je pense que la couche à *Yebisites*, au moins sa partie inférieure, est généralement synchronique.

Le Sinémurien fournissant *Arnioceras* (ARMSTRONG, 1945) est connu aux localités de Takla, Colombie britanique et au lac de Laberge, Yukon. Cependant en plusieur points du Canada, le Sinémurien est daté par *Arniotites* (*Eparnioceras*). Par exemple, la Formation de Maude à l'île de Reine Charlotte, et les schistes inférieures de Fernie sont datés comme le Sinémurien par ce genre. L'horizon presque synchronique, présisé par *Arnioceras* (inclus ses formes affines) est reconnu au Japon et sur la côte Ouest du Canada.

Harpoceras se trouve aux îles de Vancouver et de Reine Charlotte (McLEARN, 1932, p. 66, Pl. VII, Figs. 1, 2). *Harpoceras maurelli* (p. 63, Pl. VII, Figs. 4–6), *Harpoceras* sp. (p. 66, Pl. VII, Figs. 1, 2) semble *Harpoceras* s. str. du groupe d'*exaratum*, tandis que *Harpoceras* sp. (p. 70, Pl. III, Fig. 1) est trop fragmentaire pour une identification. Puisque ce genre a été fourni en association avec *Fanninoceras* et *Dactylioceras*, son âge semble un peu plus ancien que celui de notre zone à *Leioceras* (?), *Harpoceras* est connu dans le district du lac de

Tyaughton et de Takla, mais il est trop fragmentaire pour une idetification exacte. Il faut remarquer que la faune liasique supérieure, du groupe de Fernie (district de Fernie) comprend *Harpoceras* cf. *exaratum*, *Hammatoceras insigne* au dehors de *Dactylioceras* et *Dumortieria* d'après COLLET et WARREN. Cette association suggère fortement l'affinité de cette faune avec celle de la zone à *Leioceras* (?) dans notre région. *Dactylioceras* indique l'âge un peu plus ancien, mais les deux formations sont presques synchroniques. Dans le district de "White sail Lake", FREBOLD a montré la présence de *Tmetoceras regleyi* (FREBOLD, 1951, p. 18, Pl. XV, Figs. 1-4) et *Polymorphites* qui suggère l'âge aalénien, corréspondant à la zone à *Hammatoceras* de notre région.

Dans la mer Arctique, à l'île du Prince Patrick se trouve *Ludwigella* et *Harpoceras* comme déjà cité, ceci mérite de remarquer du point de vue paléogéographique.

4j. *La côte Pacifique des Etats Unis et les Montagnes Rocheuses*

Le Jurassique inférieur s'étend dans la région côtière de l'Ouest des Etats Unis et dans les Montagnes Rocheuses, et son âge est précisé par les présences sporadiques de Céphalopodes fossiles. Dans le secteur de Hawthorne et de Tonopagh de l'Ouest du Nevada, MULLER et FERGUSON ont reconnu l'Hettangien à *Psiloceras*, *Euphyllites*, *Waehneroceras* et *Schlotheimia*, qui est attribué à la base de la Formation de Sunrise. Mais comme on n'y trouve pas les formes affines d'Arietitidés, la zone à *Yebisites* semble un peu plus jeune que cette zone de Sunrise. Le Sinémurien représenté par *Arnioceras* et ses affinités est reconnu dans une partie de la Formation de Sunrise de la région de Hawthorne et de Tonopagh. MULLER et FERGUSON ont rapporté une faune qui est; *Ammonites* cf. *rotiformis*, *A. bisulcatus*, *Megarietites meridionalis*, *Amm. rotator* etc. Cette assemblage indique vraisemblablement un âge un peu plus ancien que la zone à *Arnioceras* de Kitakami. *Arnioceras humboldti* (DILLER, 1892), *Vermiceras crossmani* (DILLER, 1892) et *Arnioceras woodhulli* (DILLER, 1892) ont été recueillis au Volcano district, Nevada, et *Arnioceras nevadanus* (GABB, 1869, Pl. VI, Fig. 3) et *Coroniceras claytoni* (GABB, 1869) ont été trouvés au Volcano district. Toutes ces présences indiquent que la zone à *Arnioceras* de Kitakami correspond à une partie de la Formation de

Sunrise. Les couches correspondant à cette zone ont été reconnues en Californie, et Oregon, mais l'Ammonite indicatrice de l'âge n'y a pas été trouvée. Dans la partie supérieure de la Formation de Dunlap de Nevada, *Harpoceras* sp. a été recueilli et précise la présence du Toarcien. Dans la partie centrale et Est d'Oregon, LUPHER a établi des subdivisions du Jurassique inférieur, dans lequel *Tmetoceras* cf. *scissum* (LUPHER, 1941) a été reconnu dans le Groupe de Colpitts.

4k. *Le Méxique*

Dans le Méxique ou l'Amérique centrale le Jurassique inférieur généralement lacustre est reconnu ; celui qui est marin est connu à l'Ouest de Snonora et à la région de Veracruz, Hidalgo et Puebla. Là, la Formation de Huayacocotla est divisible en Lias inférieur et moyen. Cependant les descriptions des Ammonites ne sont pas parues, mais les zones à *Coroniceras*, *Arietites* d. gr. *sauzeanus*, et *Oxynoticeras* sont partiellement synchroniques avec notre zones à *Arnioceras*, en se basant sur la synthèse de BURCKHARDT. A l'Ouest de Sonora, *Arnioceras* a été recueilli par WHITE ; les Sinémurien est donc précisé dans cette région et dans la cordillère méxicaine.

4l. *Le Pérou*

Dans la cordillère des Andes, le jurassique est distribué de façon assez vaste le long d'une axe d'orogenèse. L'extension Nord de cette distribution se trouve dans la partie septentrional du Pérou, où on trouve le Lias inférieur. L'Hettangien est représenté par la faune de *Psiloceras* et de *Schlotheimia*. Cependant le mieux développe est le Sinémurien qui a fourni la faune caractéristique par des formes voisines d'Arietitidés. Il s'appelle " Arietenschiefer ", distribué dans la vallée du fleuve d'Utcubamba et à Bagazan. Quelques genres s'y trouvent qui caractérisent l'âge sinémurien, parmi lesquels *Arnioceras* a été bien florissant ; *Arnioceras* cf. *miserabilis* (TILMANN, p. 661), *A. ceratitoides* (TILMANN, Pl. XXI, Fig. 3), *A. angusticostata* (TILMANN, Pl. XXII, Fig. 5) sont rapportés de la vallée d'Utcubamba et *A. ceratitoides* de la région de Bagazan et à Ayasch. *Arnioceras geometricus* (JAWORSKI, 1916, p. 426) a été trouvé dans le calcaire à

Vola alata du pourtour de Huancavelica. *Arnioceras ceratitoides* ressemble remarquablement à notre espèce sur la hauteur des côtes du flanc et l'involution adulte; les "Arietenschiefer" semblent, au moins en partie, synchroniques avec la zone à *Arnioceras* de notre région.

Les *Vermiceras* et *Coroniceras*, qui représentent des ancêtres assez primitifs d'Arietitidé, se trouvent dans la vallée d'Utcubamba et dans le Pérou central; ils indiquent sûrement le Sinémurien inférieur. *Asteroceras bravoi* (TILMANN, Pl. XXII, Figs. 8a, b) provenant de St. Blas, Est de Lago de Junin. Ce genre a été trouvé dans la zone à *obtusum* en Europe; cette présence dans une localité indépendante est remarquable.

4m. *Le Chili*

En Chili, *Coroniceras* cf. *rotiformis* (MÖRICKE, p. 10), *A. bisulcatus* (HUPPÉ), "*Arietites*" (BRUGGER et DARADPSKY) ont été dejà cités; excepté *Coroniceras*, "*Arietites*" qui a été trouvé dans la vallée de la Huasco, et au Sud de Taltal, n'est certainement identifié. *Hildoceras copiapense* (MÖRICKE) se trouve à Sierra de la Ternera et près de Manflas, attribué au Lias supérieur d'après MÖRICKE; ce n'est pas exactement *Hildoceras* mais un genre qui semble proche de *Lillia*. A Sierra de la Ternera, *Leioceras subplanatum* (MÖRICKE, p. 17), *Harpoceras radians* (HUPPÉ) ont été rapportés. *Leioceras subplanatum* est obligatoirement *Harpoceras* s. str., car la figure montre les côtes assez fortes, datant le Toarcian supérieur.

Près d'Amolanas plusieurs Ammonites de l'Aalénien-Toarcien ont été trouvées. *Harpoceras proximum* GOTTSCHE (MÖRICKE, Pl. VI, Fig. 10), *Ludwigia opalinum*, *Hammatoceras planinsigne*, *Harpoceras subplanatum*, *Hildoceras copiapense* sont tous des représentants de cet âge. Quelques formes d'*Hammatoceras* sont rapportées dans "l'Eisenoolith" de Manflas, en association avec *Stephanoceras humphriesianum*. Ce sont *Hammatoceras goniotum* BENECKE (MÖRICKE, Pl. IV, Fig. 11), *H.* cf. *leptoplocum*. *H. goniotum* et *H. leptoplocum* appartiennent maintenant à *Erycites*, descendant de *Hammatoceras*, donc il n'est pas impossible tandis que fort improbable. *H. alleoni* n'est pas l'original de DUMORTIER, mais appartient peut-être à *H. semilunatum* d'après FOSSA MANCINI (1914). Mais comme on le voit, il est trop mal

conservé et mal figuré, aussi il est dangereux de corréller par cette seule présence.

4n. *L'Argentine*

Autour du passage d'Espinazito, TORNQUIST et GOTTSCHE ont reconnu l'Aalénien caractérisé par *Leioceras concavum* (TORNQUIST, Pl. I, Fig. 2) et *Tmetoceras scissum* (TORNQUIST, p. 13). Tous les deux se trouvent dans l'Aalénien (de la zone à *opalinum* et *murchisonae*); de plus, cette association est très semblable à celle de notre zone à *Leioceras* (?). Les gîtes fournissant un peu plus jeune faune sont reconnus dans les localités différentes, et sont précisées par une présence de *Sonninia*, *Emileia*, *Sphaeroceras*.

Dans le district Sud de Mendoza, le Sinémurien est précisé par *Arietites nodosarius* (JAWORSKI, 1916, Pl. VII, Figs. 2a, b). Cette espèce semble plus ancienne que notre *Arnioceras*, mais sans doute, c'est un membre d'Arietitidé. Outre celle-ci, il n'y pas de formes caractérisant le Sinémurien dans cette région. *Brodiceras* comprenant beaucoup d'espèces décrites par JAWORSKI et BURCKHARDT, est un indicateur du Toarcien-Pliensbachien, (attribués par JAWORSKI seulement pour le Lias supérieur), mais *B. tenuicostatum* est proche de notre *Leioceras* (?), jugé par son ornementation assez délicate sur le flanc. *Harpoceras subplanatum* (JAWORSKI, 1926, p. 10; BURCKHARDT, 1903, Pl. I, Fig. 3) qui est rapporté à Arroyo Calavoso, à Cerro Puchén et à Arroyo Blanco, est *Leioceras* (?), et très ressemblant avec *Harpoceras exaratum*, dont une affinité, *Harpoceras okadai*, est connu dans la région de Shizukawa. Cette espèce se trouve avec *Phylloceras partschi* et des Brachiopodes à Arroyo Blanco et à Arroyo Calavoso, qui ne sont pas les indicateurs exacts de l'âge.

Hammatoceras insigne (JAWORSKI, 1926, Pl. III, Figs. 2, 3) de Cerro Puchén est trouvé en association avec *Grammoceras* cf. *bassani* (JAWORSKI, 1926, p. 249) et *Hildoceras* (*Fuciniceras*) *meneghinianum* (JAWORSKI, 1926, Pl. IV, Fig. 14), dont le deuxième et le troisième se trouvent au Lias moyen en Europe, si les identifications sont correctement faites; et de plus, en considérant la présence de *Fuciniceras*, cet *Hammatoceras* est un représentant du Toarcien un peu plus ancien que celui trouvé en l'Asie orientale. En contradiction avec cette présence de *Hammatoceras*, BURCKHARDT a trouvé une asso-

ciation de *Hammatoceras* sp. ex gr. *insignis* (JAWORSKI, 1926, p. 224) et de *Tmetoceras* aff. *gemmellaroi* (BURCKHARDT, 1903, Pl. II, Figs. 4, 5). La présence de *Tmetoceras* suggère l'Aalénien; bien que *H. insigne* soit associé, il serait un peu moins âgé. Cela correspond assez bien à notre zone à *Hammatoceras*, même si bien que les deux zones ne sont pas complètement synchroniques. A Cerro Tricolor de Rio Grande, *Hammatoceras lotharingicum* (JAWORSKI, 1926, Pl. III, Figs. 12-3) et *H. gerthi* (JAWORSKI, 1926, Pl. II, Fig. 5; Pl. III, Fig. 2; Pl. IV, Figs. 6, 7, 16) sont reconnus avec *Fontanesia*, *Oppelia*, et *Morphoceras*. Cette coexistence indique un âge plus jeune que les couches à *Hammatoceras* dites plus haut. Ces *Hammatoceras* sont beaucoup plus évolués jugés par leur ornementation de la coquille. En outre, *Hammatoceras klimakomphalum* (BURCKHARDT, 1903, Pl. II, Figs. 1-3) est rapporté de Canada Colorado de Rio Malargué, en association avec *Harpoceras* (dont beaucoup de représentants sont mal indentifiés, et semblent comprendre *Pleydellia* (?) et des affinités primitifs de Leioceratidés). *H. klimakomphalum* est une forme évoluée parmi *Hammatoceras*, originallement décrite par VACEK de Cap San Vigilio; sa présence à cette localité suggère la période assez jeune de la durée de *Hammatoceras*. Près de Lago del Fiero, *Hammatoceras goniotum* (BURCKHARDT, 1903, p. 20) et *Leioceras* cf. *oplainum* et *Hammatoceras* cf. *lorteti*, ont été trouvés; le premier doit être rapporté à *Erycites* maintenant, mais je traiterai la couche de cette Ammonite comme du Dogger le plus inférieur, c'est-à-dire zone à *opalinum*.

Dans la région de Neuquen se trouve du Lias, il est la distribution la plus méridonale de cet âge dans l'Amérique. *Harpoceras subplanatum* (FERGULIO, 1933, p. 52, Pl. V, Fig. 6) et *Brodiceras tenuicostatum* (FERGULIO, 1933, p. 52, Pl. V, Fig. 8) sont rapportés de la vallée du Rio Genua (Patagonie); cette présence indique le Lias le plus supérieur. Il faut remarquer que *Hammatoceras* sp. cf. *sieboldi* a été trouvé entre Lingura et Pino Hachado par BURCKHARDT. Récemment MAUBEUGE rapporte trois formes aaléniennes de la province de Neuquen. Cela sont *Podagrosiceras athleticum* (MAUBEUGE, 1955, p. 621, Pl. I, Fig. 1), *Pleydellia argentina* (MAUBEUGE, p. 622, Pl. I, Figs. 2-6), et *Erycites* sp. Le premier est un genre nouveau, mais les autres sont des représentants exacts de l'Aalénien en Europe. L'Aalénien est une période de répartition la plus étendue de la mer dans la durée du Jurassique inférieur du Pacifique, on peut constater

de gisement corrélatif entre le Japon et l'Amérique méridionale.

5. Corrélation avec l'échelle européenne

Comme dit plus haut, l'échelle établie par ARKELL et aussi P. L. MAUBEUGE (plus détaillée), n'est pas complètement corrélative avec nos zonnes à Ammonites. Naturellement, il n'y a pas de même faune que celle caractérisant une zone de l'Europe, c'est-à-dire chaque zone superposée a un assemblage différent entre deux régions. Je ne peux pas, trouver des zones exactement équivalentes à celles d'ARKELL. C'est dû à la différence de la circonstance de dépôt, et aussi par la ségrégation géographique. Mais on peut dire quel âge est représenté par cette zone de Shizukawa quand on adopte la classification établie en Europe comme l'échelle absolue. Cela est représenté dans le tableau ci-après:

sauzei *sowerbyi* *murchisonae*	Zone à *Hammatoceras*
opalinum *jurense* *bifrons*	Zone à *Leioceras* (?)
——	
——	
turneri *semicostatum* *bucklandi*	Zone à *Arnioceras*
angulatum *planorbis*	Zone à *Yebisites*

Conclusions

Quand on veut saisir l'échelle stratigraphique dans une région assez distante de la localité typique, notamment de l'Europe, il faut mettre l'importance sur les faunes caractéristiques prédominantes dans telle région. Donc, j'ai essayé de saisir les faunes dominantes de la région circumpacifique. Après cette recherche, j'arrive à la conclusion suivante.

L'Hettangien est reconnu dans la région indonésienne et américaine Sud, mais il est caractérisé toujours par les faunes affines de

Psiloceratidé, rarement par le Schlotheimidé. Un ancêtre d'Arietitidé est à peine reconnu dans cette région. Cependant, la limite inférieure du Jurassique (qui a fourni des faunes de Lamellibranches au Japon), n'est pas exactement précisée jusqu'à présent. Psiloceratidés et Schlotheimidé, donc, représentent un étage dans la région circumpacifique, tandis que les Arietitidé n'y ont pas encore été florissants.

Le Sinémurien est reconnu de manière assez vaste dans le Pacifique. Beaucoup d'*Arnioceras* ou de ses espèces affines sont déjà rapportés. Ils sont trouvés non seulement dans le Pacifique Sud, mais aussi dans la région boréale, notamment en Alaska, et en Colombie britanique. Cette présence semble sûrement traduire un âge bien indépendant. Ce genre est un élément assez important de la chronologie du Pacifique.

Harpoceras et ses affinités (beaucoup de références de *Harpoceras* doivent être réexaminées, surtout pour "*Harpoceras*" et "*Grammoceras*") sont très connus dans cette région. Mais il faut noter que l'essai de corrélation doit être fait avec une restriction profonde sur les mauvaises identifications. Une coexistence de *Hammatoceras* et de *Tmetoceras* est rapportée dans une région assez limitée ; Alaska, Colombie britanique, Argentine, Japon ; qui représente exactement un niveau synchronisable. Parce que *Hammatoceras* est un genre très aisément idenitifiable, sa présence est utilisable pour une corrélation.

Phylloceratidés et Lytoceratidés sont bien florissants dans la région de la Tethys et le Pacifique, mais ils ne représentent pas un âge strictement limité. Mais leurs présence assez abondante dans la région de Kitakami montre que ces faunes sont sûrement du Pacifique ou de la Tethys.

La mer du Jurassique inférieur a eu trois maxima d'extension dans le Japon septentrional. Notamment la mer représentant par la présence d'*Arnioceras*, et puis *Harpoceras* et *Leioceras* (?) et enfin par *Tmetoceras* et *Hammatoceras*. Ce fait est bien approprié avec l'ensemble du Pacifique. Arietitidé, Harpoceratidé et *Tmetoceras* avec *Hammatoceras* sont bien florissants dans la régime Pacifique comme vu plus haut. Une seule exception est la manque complète de *Dactylioceras* et de *Coeloceras* dans la région de Kitakami. Ces deux genres se distribuent de manière vaste dans le Pacifique. Ils sont

déjà décrits de la région de Nagato du Japon occidental, et ont plusieurs formes, proches de formes indonésiennes. L'ondulation du fond marin, qui est supposée par telle répartition du Jurassique inférieur du Japon, est un caractère remarquable du Jurassique du Japon interne. Il en est même du Pliensbachien, qui est indiqué par une faune de *Fuciniceras* et de ses formes affines dans la région de Nagato, et par les éléments boréaux, c'est plus profondémment précisé par IMLAY d'après une faune d'Alaska septentrional, notamment les *Amaltheus* etc.

La retraite de la mer est connue trois fois. Il correspond à chaques niveaux manquant les fossiles marins. L'Hettangien le plus inférieur, le Pliensbachien, et le Bajocien s. s. ne fournissent pas de fossiles marins, c'est-à-dire d'Ammonite. Des couches inférieur à l'Hettangien, on peut dire le Rhétien, n'ont pas encore décisivement connu dans le Pacifique Sud-Ouest. Le " Napeng bed " de l'Indochine et de Birmanie est attribué au Norien maintenant. Ces faune de Laméllibranches sont aussi reconnus dans la région de Kitakami et aussi dans le Jurassique japonais, mais leur attribution chronologique n'est pas encore décidée. Elles ont beaucoup d'espèces fluvio-marines, du caractère transitionel entre le Triasique et le Liasique. Ce problème sera résolu après l'analyse détaillée de la faune de Lamellibranche.

Le Bajocien sensu stricto est représenté par le grès de grain gros dans la région de Kitakami. La base du grès repose sur le schiste de Hosoura avec une discordance faible. Le grès n'est pas continental, mais manque de fossiles cephalopodes ; on peut constater le retraitement de la mer au moins dans cette région.

Chapitre III. Paléontologie

La faune fossile de la Série de Shizukawa est très riche ; cependant seule une partie en a été dejà décrite. M. YOKOYAMA est le premier à avoir étudié cette faune. Malgré ses descriptions très poussées, les reconnaissances nouvelles corrigeront ses identifications et aussi ajouteront quelques espèces nouvelles.

Ici, je laisse les Lamellibranches de côté ; les Ammonites importantes pour la corrélation unvierselle, sont seules décrites. La

faune de la Série de Shizukawa est très caractéristiques par l'abondance des Phylloceratidés et Lytoceratidés. Il sont très mal consérves en général, si bien que l'on ne peut pas les identifier. En dehors des Phylloceratidés et des Lytoceratidés, les genres suivants sont reconnus; *Arnioceras*, *Harpoceras* s. str., *Leioceras* (?), *Tmetoceras*, *Hammatoceras*, *Hyperlioceras*. Tous ces genres sont caractéristiques de la région Pacifique. A de rare exceptions, tous ces éléments sont une affinité avec la faune de l'archipel indonésien en particulier. Par exemple, l'existence d'*Arnioceras*, de *Harpoceras*, de *Hammatoceras* est aussi prouvée aux îles de Rotti et de Misol etc.

Descriptions systématiques

Holcophylloceras cf. *ultramontanum* NEUMAYR

Pl. I, Fig. 1

1869 *Phylloceras ultramontanum* ZITTEL, Bemerk. über *Ph. tatricum* ecc., *Jahrb. k. k. geol. Reichs.*, Bd. XVI, p. 66, Tav. I, Figs. 4, 5.
1869 —— ZITTEL, Beob. Centr. Appen., p. 738.
1871 —— NEUMAYR, Jurastudien, p. 338.
1886 —— VACEK, Oolite v. Cap S. Vigilio, p. 65, Tav. V, Figs. 15–20.
1893 —— BONARELLI, Osserv. sul Toarciano e l'Aaleniano del App. centrale, p. 37.
1904 —— PRINZ, Fauna d. Bakony, p. 48.
1920 —— RENZ, Juraformation d. M. Generoso, pp. 550, 553.
1924 —— PARONA, Geologia, p. 425.
1927 —— SCHLOEDER, Die Amm. d. Juras. Fleckenmergel bayrisch. Alpen, p. 132, Tav. VII, Figs. 10, 11.
1937 —— NEGRI, Rev. Amm. lias, d. Lombard. occ., p. 47, Tav. IV, Fig. 16.

Un exemplaire fragmentaire, présentant les caractères de *H. ultramontanum*, c'est-à-dire, la présence des constrictions très profondes, d'allure falcifore, et qui s'infléchissent brutalement sur le milieu du flanc; la présence des côtes assez fines et nombreuses sur la partie externe du flanc etc. La ligne suturale n'est pas observable sur tous nos échantillons, mais elle indique l'affinité avec *H. ultramontanum* en raison de ce que les constrictions n'accompagnent aucun côte plus forte, et se projètent au milieu du flanc.

Le détail de l'aspect de la coquille n'est pas obtenu sur cet échantillon mal conservé, aussi la référence spécifique est-elle impossible. L'espèce est citée assez abondamment dans la région méditérranéenne mais est inconnue dans l'Europe Nord et Est. Il y a quelques formes de *Holcophylloceras* dans la région du Pacifique

Sud, d'où BOEHM, KRUIZINGA et KRUMBECK etc. en ont rapporté quelques-unes. En particulier *H. insulindae*, qui provient de l'île de Sula du Callovien inférieur, est bien ressemblant avec notre espèce. Mais il diffère assez nettement par les constrictions un peu plus profondes et ondulées, associées à de faibles plis, et par les côtes un peu plus fortes sur le flanc, au moins sur le flanc intérieur.

La présence de cette espèce joue un rôle assez important dans la corrélation des régions du Pacifique Sud. Car, les *Phylloceras* sont des éléments très importants de la faune méditérranéenne; et d'autre part la faune de Kitakami a nettement un caractère méditérrano-Pacifique, et non pas Nordique ou boréal.

Provenance:—Loc. 5324, Hl, Sodeyama.

Holcophylloceras sp.

Pl. I, Fig. 2; Pl. II, Fig. 10

Appartenant sûrement à *Holcophylloceras*, notre forme diffère de l'espèce précédente par l'absence des côtes sur le flanc extérieur et les constrictions moins nombreuses et beaucoup moins ondulées. Elle est plus proche du groupe de *Holcophylloceras mediterraneum* que de celui de *H. ultramontanum*, dans l'ornementation de la coquille, mais assez différente dans la forme du tour, qui est plus comprimée, et dont le flanc est beaucoup moins renflé. Quelquesuns de ceux qui sont pourvus de telles constrictions sans le coude qui se projète au milieu du flanc, par exemple, *polyolcum*, *silesiacum*, *torulosum*, *eastoni* etc., ont un flanc tout renflé.

Dans la faune du Pacifique Sud, *Holcophylloceras malayanum*, *mamapiricum*, et *taliabuticum*, sont ressemblants à notre forme, mais il sont tous pourvus des côtes assez fines et nettes.

En raison de la conservation en mauvais état, on ne peut pas décider de sa position spécifique. Mais il ne reste aucun doute pour le mettre dans le genre *Holcophylloceras*, car, il a été trouvé dans la partie supériure de la Formation de Hosoura, qui est envisagée en connexion avec la mer du Pacifique Sud.

Provenance:—Loc. 5303, 5307; Village de Hosoura, Hh.

Phylloceras sp.

Pl. I, Fig. 6

Fort déprimé et déformé, ce spécimen ne peut pas être appartenu

à un genre ou sous-genre décisif. La coquille lisse, quelquefois ornée des stries très fines et serrées vers la péristome, et l'ombilic très étroit sont du caractère de *Phylloceras* sensu lato. Beaucoup d'éléments suturals indique aussi celui de ce genre.

Provenance:—Loc. 0412, côte Est de Hosoura, Hl.

Kallilytoceras sp.

L'auteur a récolté quelques échantillons de cette espèce dans la région de Hosoura, qui sont tous fragmentaires, difficiles à déterminer spécifiquement; il est véritablement la même espèce que celle de YOKOYAMA (1904), mais n'est vraisemblablement pas la même espèce que *Lytoceras lineatum*. Il présente le caractère suivant; les stries simples et très fines, périodiquement intercalées entre des côtes ridées et quelques côtes élevées, minces. Ces caractères suggèrent l'affinité pour *Kallilytoceras* BUCKMAN 1921. Il est très particulier, néanmoins, que les côtes ridées sont plus serrées près de l'embouchure du tour. La moule interne est tout à fait lisse. Quoique je n'ai pas encore précisé les caractères décisifs, je tiens à citer cette forme comme *Kallilytoceras* surtout au point de vue de l'ornementation.

Provenance:—Lec. 0421, côte Est de Hosoura, Hh.

Arnioceras yokoyamai (MATSUMOTO)

Pl. I, Figs. 3, 4, 5

1953 *Asteroceras* (?) *yokoyamai* MATSUMOTO, Jurassique, Histoire géologique, p. 368.

Diagnose:—Coquille discoïde, très évolute. La spire croît assez rapidement; section du tour subquadrangulaire ou quelquefois elliptique, convergente; chute du tour sur l'ombilic verticale; son bord est arrondi. La région periphérique bien définie est pourvue d'une forte carène, haute, bordée de sillons assez profonds et étroits. Les côtes sur les flancs sont simples, très distantes, les plus élevées sur la région ventro-latérale en formant la carène accessoire près du sillon. Le nombre de côtes sur le dernier tour est de 16 mais elles sont plus nombreuses sur les tours internes. La ligne suturale est simplement découpée: Lobe ventral moins ou aussi profond que le lobe latéral; Lobe latéral étroit et profond, trifurqué. Selle ven-

trale haute et vaste mais moins haute que la selle latérale, et divisée au sommet par un lobule ; lobe ombilique petit et un peu incliné.

Remarque :—*Asteroceras yokoyamai* est cité par MATSUMOTO en 1953 ; son spécimen est récolté dans la même localité ; la ligne suturale cité par MATSUMOTO présente le lobe latéral moins profond que celui de notre spécimen. Cela indique qu'il ne faut pas prendre la longueur du lobe latéral comme un caractère générique décisif.

Rapports et Affinité :—Cette espèce est très ressemblante à *Arnioceras*, par les caractères suivants : les spires très évolutes, la section du tour quadrangulaire et convergente, les côtes très saillantes, minces, et simples, leur infléxion et la ligne suturale ; mais différente par la croissance du tour plus ou moins rapide, les côtes plus saillantes sur la région ventro-latérale. Cependant, l'auteur mit cette espèce très proche d'*Arnioceras*, parce que les ornementations et structure interne sont strictement affines entre les deux formes.

Les espèces des genres créés par BUCKMAN et SPATH, c'est-à-dire *Epammonites*, *Eparnioceras*, *Arnioceratoides*, sont tous différents par leurs côtes et l'aspect ventral.

Parmi les espèces d'*Arnioceras*, *Arnioceras* cf. *fortunatum* rapporté par JAWORSKI de l'île de Rotti, est très proche. Cependant il ne correspond pas exactement *A. fortunatum* créé par BUCKMAN ; les côtes sur la région ventro-latérale indiquent une ressemblance avec l'ornementation de notre espèce. De plus, d'autre côté, *A. rejectum* FUCINI, *A. boddeni* TUTSCHER-TRUEMAN sont intimes avec notre espèce : mais ils diffèrent par les sillons ventraux très étroits et les côtes beaucoup plus hautes sur la région ventro-latérale.

Provenance :—Loc. 120, 123, 131, 125, Nakazaï ; Loc. 17, Côte Est de Hosoura ; Ha.

Harpoceras s. str. *okadai* (YOKOYAMA)

Pl. II, Figs. 9, 10

1904 *Grammoceras okadai* ; YOKOYAMA, Jurassic Ammon. from Echizen and Nagato, *Jour. Coll. Sc., Imp. Univ., Tokyo, Vol. 19, Art. 20*, p. 14, Pl. IV, Fig. 3.

1947 *Pseudolioceras okadai*, MATSUMOTO et ONO, Biostr. Study Juras. Toyora Gr., *Study Rep. Coll. Sc., Kyushu Univ., Vol. 2, pt. 1*, p. 29, Pl. I, Fig. 8.

Cette espèce a le caractère du genre *Harpoceras* sense stricto, qui est caractérisé par les côtes très fines, délicates et ondulées

comme les "falciferi", une carène sur la région ventrale, une section des tours assez mince et la ligne suturale plus ou moins découpée. Elle est très proche de *H. exaratum*, (*Harpoceras* s. str.), provenant de l'Ouest de l'Europe.

C'est la première décrite par YOUNG et BIRD qui a donné le groupe de l'Ammonites, *Harpoceras exaratum*, avec les caractères suivants: d'après la description originale, "backward sloping inner angle of the whirls, less inner whirls, more uniformly grooved furrows". Pourtant, on peut confondre ces caractères avec ceux d'autres espèces, par exemple, *complanatus*, *elegans* et *subplanatus* par D'ORBIGNY, REYNÈS, et DUMORTIER etc., car YOUNG et BIRD n'ont pas représenté de figure pour l'Holotype. Ils n'appartient pas aux autres espèces indépendantes, comme Th. WRIGHT l'indiqua, mais à *H. exaratum* en tout cas, si l'on reconnait l'existence des sillons ventraux, et la faiblesse des ornements sur les flancs.

En 1904 YOKOYAMA a décrit *Grammoceras okadai* dans le Jurassique à Nishinakayama, Nagato, qui est une coquille jeune et dont la partie interne du flanc est dépourvue de côtes fines, et plus ou moins lisse. MATSUMOTO et ONO ont recueilli beaucoup de spécimens de cette espèce dans la même localité, surtout un individu qui est très ressemblant à notre spécimen de la même espèce.

L'espèce provenante de Hosoura, est un moule interne adulte et un jeune, qui sont tous deux incomplets, et représentent le caractère de *H. okadai*, comme il suit; l'involution très poussées (ombilic très étroit), les côtes très fines et très délicates qui sont un peu moins ondulées que celles de l'espèce typique de *Harpoceras*, une unique carène sur la région ventrale. Bien que ces spécimens soient assez mal conservés, ils indiquent une relation très proche avec *H. exaratum* par les caractères cités plus haut. Il y a un autre *Harpoceras* sensu str. dans la faune de Nagato; c'est *H.* aff. *exaratum* provenant de la même localité, qui a été d'abord rapporté par YOKOYAMA comme *Harpoceras* sp. Il diffère de notre espèce et de celle de Nagato par les côtes plus distantes, plus élevées, et plus fortement ondulées.

Dimensions:—en mm.

	D.	D.O.	H.	E.
0489	136,5	ca 21,0	72,0	?
5312	ca 50	10	ca 21	?

Provenance:—Loc. 0489, Côte de Gongen, Hl; Loc. 5312, Hl, Jawô.

Hyperlioceras sp.

Pl. II, Figs. 7, 8

Comme nous n'avons que des spécimens fragmentaire, l'auteur ne peut pas détérminer sa position systématique exacte. Même si l'on néglige les jeunes, les ornements des spécimens adultes représentent les caractères de *Hyperlioceras*, jamais de *Ludwigia*, non plus de *Leioceras*. C'est-à-dire les flancs sont étendus et peu renflés, ornés des côtes ondulées sur la partie externe, et de stries fines (côtes très fines) sur l'interne; la carène est haute et solide; l'involution très limitée. Les caractères importants de *Hyperlioceras*, notamment l'aplatissement de la région ventrale, la concavité de la suture ombilicale, etc. ne sont pas visible dans nos récoltes.

Quelques espèces de *Ludwigia* sont ornées de façon assez similaire; et souvent les auteurs englobent dans ce genre *Leioceras* et *Hyperlioceras* et plusieurs petits genres créés par BUCKMAN. Mais j'ai reconnu que *Hyperlioceras* soit être séparé comme le fait BUCKMAN, par ses ornements, la forme des tours, la structure interne, distingués très nettement, tandis que j'ignore un groupe de petits genres de BUCKMAN.

Provenance:—Loc. 0422, 5312/1, 5324, Hl, Hh.

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Post Scriptum:—Tandis que les fossiles lamellibranches de la formation de Niranohama, sauf la faune de Trigonidés, sont écrits comme *non marin*, il faut corriger profondémment, grâce à l'étude très poussée de M. I. HAYAMI, leurs attributions génériques et spécifiques pour tous *marins*, par exemple, *Isognomon, Bakevellia, Gervillia, Eomiodon,* et également ajouter quelques espèces neuvelles. Il en est même de la faune des groupes de Kuruma et Iwamuro; par conséquent, on ne pouvait pas trouver les lamellibranches non marins dans le Jurassique inférieur du Japon.

Référez; I. HAYAMI: *Japan. Jour. Geol. Geogr., Vol. XXVIII, Nos. 1–2; Trans. Proc. Pal. Soc. Japan, N. S., No. 27 et 28.*

T. Sato

Biostratigraphie de la Série de Shizukawa
(Jurassique inférieur) du Japon Septentrional

Planche I

Explication de la Planche I

Holcophylloceras cf. *ultramontanum* Neumayr

Fig. 1. Loc. 5324, Hl, Col ouest de Sodeyama, ×1.

Holcophylloceras sp.

Fig. 2. Loc. 5303, Hh, Village de Hosoura, ×1.

Arnioceras yokoyamai (Matsumoto)

Fig. 3. Loc. 0417, Ha, Côte est de Hosoura, relevant les cloisons, ×1.

Figs. 4a, b. Loc. inconnue, récolte ancienne de l'Institut, ×1.

Figs. 5a, b. Loc. 08125, Ha, Nakazaï, moule de gypse, ×1.

Phylloceras s. l. sp.

Fig. 6. Loc. 0412, Hl, Côte est de Hosoura, ×2/3.


1

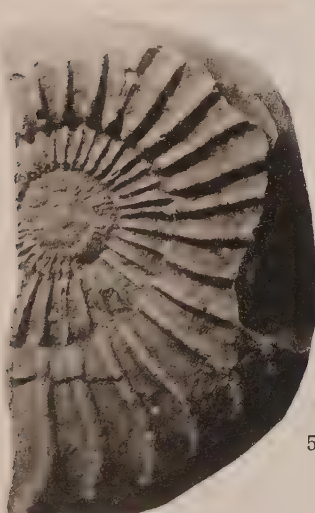

2

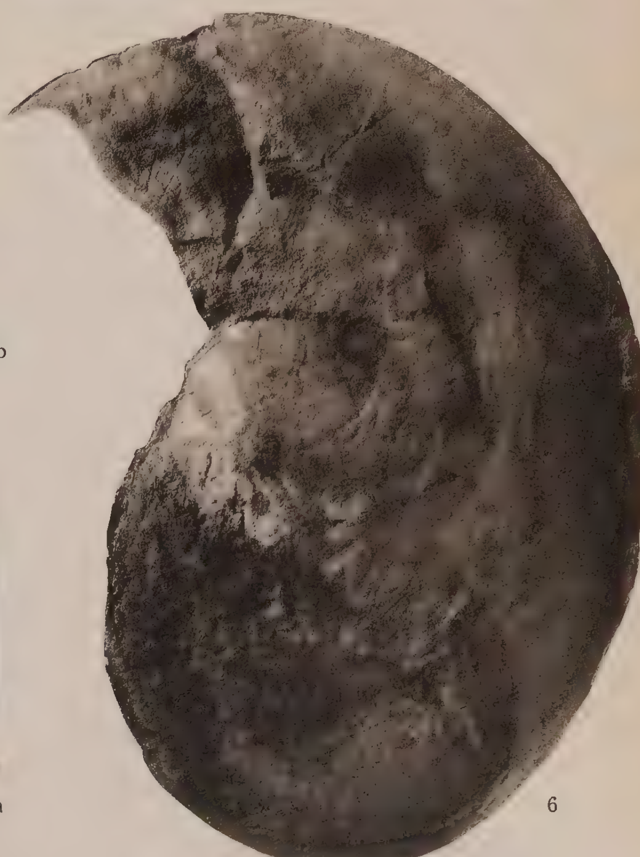

3


4a


4b


5b


5a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T. SATO

Biostratigraphie de la Série de Shizukawa
(Jurassique inférieur) du Japon Septentrional

Planche II

Explication de la Planche II

Hyperlioeras sp.

Fig. 7. Loc. 0422, Hl, Côte est de Hosoura, ×1.

Fig. 8. Loc. 5311/1, Hh, Hosoura, ×1.

Harpoceras okadai (YOKOYAMA)

Fig. 9. Loc. 5312, Hl, Jawô, village de Hosoura, ×1.

Fig. 10. Loc. 0489, Hl, Côte de Gongen, ×3/4.

Holcophylloceras sp.

Fig. 11. Loc. 5301, Hh, Village de Hosoura, ×3.

Jour. Fac. Sci., Univ. Tokyo, Sec. II, Vol. X, Pt. 3, Pl. II.

7

8

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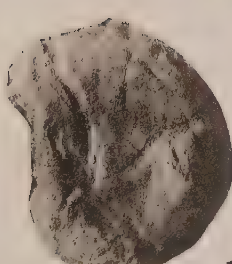

11

Cl. Ueki

A Trigonian Faunule from Mindoro in the Philippine Islands*

By

Teiichi KOBAYASHI

With one Plate

Little is known of the pre-Tertiary stratigraphy of the Philippine islands. There is a chert-bearing formation variously called Babuyan, Mirinduque or Negrito (HASHIMOTO, 1939, 41). When SMITH found *Cenosphaera affinis* HINDE and *Dictyomitra tenuis* HINDE in the series on Panay and Balabac islands, he correlated it to the Franciscan group in California and considered it to be Jurassic, the age determination being, however, a matter of discussion (KOBAYASHI and KIMURA, 1944).

No other pre-Tertiary fossil had ever been known for a long time until VILLA discovered perisphincti and some other Molluscan remains at Mansalay in Mindoro island in 1937. Lately the existence of the Cretaceous formation was proven in the Philippines with the find of *Orbitolina* limestone in Cebu (TEVES, 1953).

On the occasion of the Eighth Pacific Science Congress at Quzon City, 1953, I had a happy opportunity to see a fossil collection of Mindoro deposited in the Bureau of Mines at Manila and to make replicas for study for the facility of which I wish to tender my sincere gratitude to Dr. Jean S. TEVES of the Bureau. My thanks are also due to Mr. J. KATTO of the Kochi University for the study of *Solemya murotoensis*, nov.

The Trigonian Faunule of the Amaga River

According to VILLA (1944) there are two ammonites-bearing formations in Mindoro. One is his Mansiol shale and mudstone

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* Received Jan. 31, 1957; read in the Annual Meeting of the Palaeontological Society of Japan at Tokyo, Feb. 9, 1957.

formation exposed on the southeast coast of Mindoro between Colasi Point and Mansiol Point and yields Callovian (?) *Macrocephalites* and *Oppelia*. The other is the Mansalay formation fairly extensive in the south of Mansalay and a few other places in the same island. It is composed of conglomerate, sandstone and shale. In the black shale member there is an ammonites bank whence perisphincti and other Molluscs were collected and the Oxfordian age was suggested for the fauna by VILLA.

None of them, however, has been described except *Trigonia mindoroensis* HAYASAKA (1943) which is a member of the Mansalay fauna. As pointed out already (KOBAYASHI and MORI, 1955), it is a typical *Vaugonia*, but *Vaugonia* as a genus ranges widely through the Jurassic period. Dating of *V. mindoroensis* by its morphic resemblance with any species in a remote place is not very reliable.

Lately RIVERA (1954) gave a brief note on the fossils from Mindoro. According to her there are various ammonites indicating geological ages from upper Lias to Tithonian. Further, it is stated that "Lot No. 6 contains several specimens of *Trigonia* all of which appear to belong to one species. This *Trigonia* resembles *T. literata* YOUNG and BIRD, and according to the recent classification of *Trigonia* by COX, it will fall into the genus *Myophorella*, subgenus *Vaugonia*". Because the species in question is compared with *Trigonia literata*, it belongs probably to the subgenus *Hijitrigonia* of the genus *Vaugonia*, instead of the genus *Myophorella*, in my classification. This means that it may be different from not only *Vaugonia* (*Vaugonia*) *mindoroensis*, but also any of the below listed Trigonian species.

The collection which I have seen at Manila is neither VILLA's, nor RIVERA's but a new one which comprises three sets of fossils. Namely, one consists of Trigonians and other pelecypods contained in "*Floats on the Amaga river, Mindoro island*," another of ammonites and still another of a slate slab containing *Solemya*. Because I had carried out a study on the Trigonians in Japan, I extended my investigation into the Trigonian faunule of the Amaga river. As the result the followings were distinguished in it:

1. *Rutitrigonia yeharai* KOBAYASHI
2. *Rutitrigonia amagensis* KOBAYASHI, new species.
3. *Latitrigonia multicostata* KOBAYASHI, new species.
4. *Nipponitrigonia* (?) sp. indt.
5. *Myophorella* (*Promyophorella*) *orientalis* KOBAYASHI and TAMURA

6. *Myophorella* (*Promyophorella*) new species.
7. *Chlamys* (*Radulopecten*?) *villai* KOBAYASHI, new species.
8. *Chlamys* sp. indt.

As discussed in a recent paper of mine (1957), *Rutitrigonia* is a cosmopolitan genus in the Cretaceous period, but *R. yeharai* is a lower Neocomian species.

Myophorella or even its subgenus, *Promyophorella*, is widely ranged from upper Lias to Lower Cretaceous, but the distribution of *Myophorella* (*Promyophorella*) *orientalis* is restricted in Japan to upper Malm. More precisely, it occurs in the Jurassic of Soma, North Japan, in the Koyamada formation at the top which is considered Tithonian in age. In the southern Kitakami region it is known from the upper Kogoshio formation and the Tashiro formation the age of which is Tithonian or/and Kimmeridgian. In Japan *Promyophorella* or *Myophorella* is well represented by several species in the Middle and Upper Jurassic formations, but none is known from the Cretaceous deposits.

Latitrigonia ranges from Middle to Upper Jurassic and *L. tetoriensis* to which *L. multicostata* is allied, occurs in the Yambarazaka sandstone at the top of the Kuzuryu stage of the Tetori series in Prov. Echizen, Fukui Pref. The sandstone is judged to be upper Malm from the occurrence of *Katroliceras yokoyamai* KOBAYASHI and FUKADA (1947) in the subjacent beds. *Nipponitrigonia* occurs in Japan in the Middle (?) and Upper Jurassic and Lower and Middle Cretaceous, but not in the Upper Cretaceous rocks.

There is no other species or genus of great importance for chronology. It is, however, quite warranted by these facts that the age of the Amaga faunule is somewhere in a range from Tithonian to lower Neocomian. Because the fossils are in fluviatile boulders, it remains to be a question, whether they were derived from two or more fossiliferous horizons in the above mentioned time range, or whether there is only a passage bed from Malm to Neocomian in which the late Jurassic and early Cretaceous elements are coexistent.

In the Sakawa basin, Shikoku, Japan, *Nipponitrigonia* cfr. *kikuchiana*, *N. convexa* and *Rutitrigonia yeharai* are found together with *Pterotrigonia pocilliformis* var. in the Yamanokami sandstone which is considered the marine facies of the Wealden or lower Neocomian

Ryoseki series (KOBAYASHI, 1932). Acçording to KIMURA's detailed survey (1956) this sandstone conformably overlies the Kambaradani shale and the latter in turn lies on the Kambaradani sandstone containing *Aulacosphinctoides* cfr. *steigeri* SHIMIZU which is a Kimmeridgian ammonites (KOBAYASHI, 1935). Therefore the Kambaradani shale is most probably Tithonian and may be correlated with the Trigonian sandstone of the Amaga, if the above fossils were derived from a fossil bed.

Finally, a few words are added here as to *Solemya* sp. It is contained in a small slab of dark gray somewhat slaty shale, as commonly seen in Japan in the so-called Shimanto and Nakamura groups i. e. the unclassified Mesozoic-Palaeogene formations in West Japan. Its lithology reveals that the slab came from a formation different from either the ammonites or the Trigonian beds. The life range of *Solemya* is from Cretaceous to Recent and its subgenus *Acharax*, to which the pelecypod in question probably belongs is a mud-lover in a few hundred fathoms to the abyssal depth. Therefore it is presumed that a float of the *Solemya* shale on the Amaga river was derived from somewhere in a Flysch type of sediments younger than the Trigonian sandstones. Assuming that the Ammonites beds are all Jurassic, it is reasonable to consider that the Trigonian sandstone of the Amaga indicates the marine regression of the Oga phase at the end of the Jurassic period. (KOBAYASHI, 1941).

Description of Fossils

Family Solemyacidae

Genus *Solemya* LAMARCK, 1818

Subgenus *Acharax* DALL, 1908

Solemya (*Acharax*) *johnsoni* DALL is the type species of the subgenus. This as well as *S.* (*A.*) *agassizi* DALL are said to have been dredged from a sea bottom, more than 1,000 fathoms deep, from fine mud or soft ooze. In Japan there are 3 living species of *Solemya* (KURODA and HABE, 1952) and *S.* (*A.*) *tibai* KURODA (1948) was collected from off the Erimo cape, southern Hokkaido at the depth less than 250 fathoms.

In the Tertiary of Japan the subgenus is represented by two

Miocene species, i.e. *S.* (*A.*) *tokunagai* YOKOYAMA (1925) and *S.* (*A.*) *yessoensis* KANEHARA (1937) where the former has a very wide distribution. From their associate shells KANEHARA noted that the great depth like an abyss is not indispensable for *Acharax* or *Solemya* to live, but it requires a fine mud or silty facies of fair depth.

In these Tertiary species periostracum is sometimes shown to be protruded ventrally into processes, but such projections are unpreserved in *Solemya angusticaudata* NAGAO (1932) and other Cretaceous species in Japan.

NAGAO's species from the upper Ikushumbetsu river has radial grooves distributed with irregular intervals, more densely in the posterior than in the median part. His Pombetsu specimen (1938) is too badly deformed to make specific identification. *S.* cfr. *angusticaudata* by NAGAO and OTATSUME (1938) is represented by an imperfect cast from Hetonai which is similar to *Solemya* (*Petrasma*) *labeosa* YOKOYAMA (1928) in size and undeveloped radial markings, although they are easily distinguishable from each other by the difference in outline.

Lately *Solemya angusticaudata* was reported by KATTO and OZAKI (1956) from two localities in Southern Shikoku. Through the courtesy of Mr. J. KATTO of the Kochi University I could examine the specimens. *S.* (*A.*) *murotoensis* nov. is established here for the specimens from the Muroto cape because KATTO turned over to me the privilege of its determination. The other was procured at Utsuno tunnel, south of Kochi city, from the upper division of the Shimanto group. (KOBAYASHI, 1957.) This is too strongly deformed to figure out its original outline, but undoubtedly it is specifically distinct from the Muroto form, because radial grooves are well marked all through the shell. They are distributed almost equidistantly in the Utsuno form, while the intervals are very irregular in breadth in *S. angusticaudata*. The Utsuno form appears closer to *S.* (*A.*) *tokunagai* than *S. angusticaudata* in the strong radial channels, but the bands and channels are more numerous and the channels are always narrower than the bands in the Utsuno form, while the channels are sometimes broader than interspaces in the anterior in *S. tokunagai*.

It is probable that the morphic difference between the Utsuno and Muroto forms corresponds to the time displacement between the Shimanto and Nakamura groups to the latter of which the

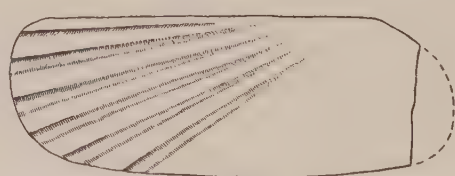
Muroto formation belongs.

Solemya (*Acharax*?) *murotoensis* KOBAYASHI, new species

Plate III, Figures 17–18; Text-figure 1.

1956 *Solemya angusticaudata* by KATTO and OZAKI, non NAGAO, *Res. Rep. Kochi Univ. Vol. 5, No. 10*, p. 2, figs. 1–2.

Shell long and slightly inflated; umbo very excentric; antero-dorsal margin straight, longer than twice the height; anterior margin subvertical, gently arcuate, forming an obtuse angle with dorsal one and by increasing curvature downward, passing into ventral margin which is almost parallel to dorsal one; posterior margin gently slant from umbo; posterior outline unknown; shell length presumably three times longer than shell height; 7 channels and 8 bands radiating antero-ventrally in umbonal angle of 50 degrees; the former narrower than the latter near dorsal margin, but almost as broad as the latter on the other side; these radial sculptures strengthened from umbo to periphery; median and probably posterior part smooth or radial markings only very feebly impressed near ventral margin.



Text-fig. 1. *Solemya* (*Acharax*?) *murotoensis* KOBAYASHI, new species

This species is represented by three specimens, none of which, however, shows the posterior portion. The type left valve is 14 mm. high and its pre-umbonal margin about 32 mm. long. This can easily be distinguished from *S. angusticaudata* by its taller and parallel-sided outline and the absence of radial markings in the median part.

Locality:—Black shale of Muroto formation at Sakamoto village, Muroto-town, Aki-county, Kochi Prefecture, (Tosa Province). The age of the formation has been undetermined, but must be Cretaceous or Palaeogene, because it yields *Solemya* and it is overlain discordantly by the Miocene Shijujiyama formation.

Solemya sp. indt.

Plate III, figure 16.

The Amaga specimen is so fragmentary that the outline of the shell can hardly be restored. It is somewhat similar to *Daonella*, but can readily be distinguished from that genus by its broad soleniform shell, very excentric umbo and broad radial channels. In my opinion it is more probable to belong to *Solemya* than any other genus and if so, appears likely a member of *Acharax*, although nothing is known of its ligament.

The imperfect right valve is gently inflated and 8 channels and 8 bands are found in the antero-dorsal part. A channel is narrower than a half of a band near the dorsal margin, but the breadth becomes greater on the other side as far as it attains about a half of a band. There a narrow median ridge may be present on the bottom of the channel. The radial markings become, however, very weak in the median part. The specimen is evidently larger than any Cretaceous specimen in Japan.

Family Trigoniidae

Trigonians are rather uncommon in this part of Asia (WANNER, 1931). *Prorotrigonia seranensis* (KRUMBECK) and *Prosogyrotrigonia timorensis* KRUMBECK respectively from the Noric of Seram and the Rhaetic of Timor are two old aberrant forms.

WANDEL (1936) has described *Trigonia tenuicosta* LYCETT from the *Harpoceras* shale and *Trigonia moorei* LYCETT from the *Hammatoceras* beds in Misol. As noted already (KOBAYASHI and MORI, 1954), WANDEL's *moorei* agrees fairly well with the lectotype of LYCETT's *moorei*, both evidently belonging to *Trigonia* s. str., i. e. *Lyriodon*. *Trigonia moorei* LYCETT occurs at Geralton, Western Australia, in the Champion Bay group (Kojarena sandstone and Colalura sandstone) and proved to be Bajocian in age (ARKELL and PLAYFORD, 1954). Prior to WANDEL, SOERGEL (1913) reported *Trigonia* (s. str.) cfr. *similis* AG. to occur in Misol in the *Prodicoelites* and *Belemnopsis persulcata* bearing limestone and marl (Bathonian).

The age of the Molluscan fauna in western Borneo which comprises *Exelissa*, *Protocardia* and other shells has been a subject of

dispute. While VOGEL (1890, 1900) took it for White Jura, NEWTON (1903) considered it to be Lower Oolite. The Bathonian age of the fauna was upheld by GRABAU (1928). "In later years these fossils proved to occur also in the Lower Cretaceous so that the Jurassic age of these areas is no longer proved (Zeylmans VAN EMMICHOVEN, 1938)" (VAN BEMMELEN, 1949, p. 64).

NEWTON emphasized the Lower Oolite age of the fauna, when he described *Trigonia molengraffi*, with the statement that "Since its main characters are only to be found in forms common to the Bajocian or Bathonian strata of the Jurassic system". (NEWTON, 1903, p. 409.) It can, however, hardly be overlooked that the resemblance of *T. molengraffi* is much closer with *Myophorella* (*Haidaia*) *crenulata* than with European Clavellatae (*formosa*, *phillipsi* and *moutieriensis*). Because *orientalis* occurs in the *Lima* sandstone of the Nakanosawa formation in the Soma area, Fukushima Prefecture which is considered middle Malm (Oxfordian-Kimmeridgian), I think that the age of *molengraffi* may not be much deviated from *orientalis*.

Finally, *Trigonia limbata* D'ORBIGNY is known from the Rudistid formation (Cenomanian) of Martapoera (MARTIN, 1889) in Southeast Borneo and *Trigonia* cfr. *limbata* from the upper Seberuang (Senonian) stage in West Borneo (GEINITZ, 1883). *T. limbata* D'ORBIGNY is a Pterotrigonian occurring in Europe in various Cretaceous formations, Cenomanian and later. While the one from Martapoera is illustrated, the other is only listed.

MARTIN's Martapoera form is a Pterotrigonian having diagonal costellae on the concave area. (See Fig. 14, Taf. XVI.) These costellae are simple and less numerous and significant than those of *Acanthotrigonia moriana* (YEHARA). Some 26 costae on the disk are distinctly crenulate. The sculpture, outline and convexity of the shell show that its close affinity with *Acanthotrigonia moriana* from the Albio-Aptian Miyako series in Eastern Tosa, Shikoku.

Genus *Latitrigonia* KOBAYASHI

Latitrigonia multicostata KOBAYASHI, new species

Plate III, figure 3.

Shell subquadrate and moderately convex; umbo small, located at about a third the shell length from front; area nearly half as

large as the disk; cardinal and median carinae obscure, but posterior area is distinguishable from anterior by its concavity; escutcheon fairly large, concave and clearly separated from area by tuberculate inner carina; costae some 12 in number, somewhat flexuous, narrower than their intervals.

This is more or less similar to *Latitrigonia tetoriensis* KOBAYASHI (1957), but can easily be distinguished by more numerous costae and other features.

Occurrence:—Float on the Amaga river, Mindoro.

Genus *Nipponitrigonia* COX

Nipponitrigonia (?) sp. indt.

Plate III, figure 12.

Though this is a fragmentary right valve, it appears to be a Trigonian resembling *Nipponitrigonia* (?) *sakamotoensis* (YEHARA). The disk is ornamented by flat-topped concentric costae which become obsolete in the mesio-anterior part; area of moderate size, somewhat concave and defined by a blunt marginal angulation. The umbo is possibly opisthogyl, insofar as can be judged from the curvature of the angulation.

Occurrence:—Same as the preceding.

Genus *Rutitrigonia* VAN HOEPEN

Rutitrigonia yeharai KOBAYASHI

Plate III, figure 1.

1923 *Trigonia neumayri* YEHARA, non CHOFFAT, *Japan. Jour. Geol. Geogr. Vol. 2*, p. 82, pl. 9, figs. 1–3.
1954 *Rutitrigonia yeharai* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 25*, p. 74.
1957 *Rutitrigonia yeharai* KOBAYASHI, *Trans. Proc. Pal. Soc. Japan, N.S. No.* 26, p. 59, pl. 10, fig. 1.

As a detailed description of this species was given in the third paper, any repetition is here avoided. A small Trigonian from Mindoro has a moderately convex and distinctly rostrate shell with a relatively large umbo. Subconcentric costae in the anterior part are fine, somewhat flexuous and widely spaced. Compared with the typical *yeharai* in Japan, its umbo is a little larger and the costae

become obsolete already below the umbo, while they persist a little longer in the Japanese form. Otherwise this agrees with the Japanese form very nicely. Therefore the minor difference may be no more than an endemic variation.

Occurrence:—Float on the Amaga River, Mindoro. This species occurs in the Sakawa basin, Shikoku in the lower Neocomian Trigonian sandstone at Yamanokami of Nagano in association with *Nipponitrigonia convexa* and *Pterotrigonia pocilliformis* var.

Rutitrigonia amagensis KOBAYASHI, new species

Plate III, figure 2.

Shell gently convex and dilating posteally, but not so remarkably rostrate as the preceding species; its umbo smaller than that one; subconcentric costae more than 15 in number, coarser than those of the preceding species, but seemingly weak near the umbo, a little wavy and become evanescent on the posterior side. This has a blunt angulation. The costae become obsolete near the vertical through the umbo. Behind this line and especially on the area fine lines of growth are tolerably well impressed.

Occurrence:—Float on the Amaga River, Mindoro.

Genus *Myophorella* BAYLE

Subgenus *Promyophorella* KOBAYASHI and TAMURA

Myophorella (*Promyophorella*) *orientalis* KOBAYASHI and TAMURA

Plate III, figures 5–8.

1925 *Trigonia formosa* by SHIMIZU, non LYCETT, in YABE and AOKI, *Japan. Jour. Geol. Geogr. Vol. 3*, p. 31, pl. 3, figs. 3a–c.

1955 *Myophorella* (*Promyophorella*) *orientalis* KOBAYASHI and TAMURA, *Japan. Jour. Geol. Geogr. Vol. 26*, p. 98, pl. 5, figs. 6a–b.

Several imperfect specimens from the Amaga reveal different parts of this species, as can be recongnized their comparison with the nearly complete left valve from Soma in fig. 4. They have regularly tuberculate costae which are somewhat roof-shaped and widely spaced; marginal and inner carinae also tuberculate; median groove in place of the carina divides the area into a broader anterior and a narrower posterior band.

In the specimen in fig. 7 the transverse costellae are broadly spaced, but in the other in fig. 5 they are even denser and finer than those of the Japanese form.

Occurrence:—Float on the Amaga River, Mindoro. This species is widely distributed in the upper Malm in North Japan. The type locality of the species is in the Soma area of Fukushima Prefecture where it occurs in the 9th Trigonian zone in the Koyamada formation. In the Southern Kitakami Mountains it is known from the Upper Kogoshio and Tashiro formations.

Myophorella (*Promyophorella*) sp. nov.

Plate III, figres. 9–10.

The specimen in fig. 9 is similar to the preceding, but essentially distinct in the entirely smooth area and the lack of the marginal carina. Additional distinctions are much finer costae, neat tubercles on them and broad and flat interspaces in which respects the other specimen in fig. 10 appears to agree better with this than the preceding species. This species is evidently new to science, but the specimens are unfortunately too poor to give a name.

Occurrences:—Float on the Amaga River, Mindoro.

Subgenus *Haidaia* CRICKMAY
Myophorella (*Haidaia*) *molengraffi* (NEWTON)

Plate III, figure 4.

1903 *Trigonia molengraffi* NEWTON, *Proc. Malacol. Soc. Vol. 5*, p. 405, pl. 16, figs. 1–6.

Original diagnosis runs as follows:—

Shell small, ovately trigonal, moderately convex, and of nearly equal height and length; anterior border rounded, posterior end truncated; umbones almost mesial, obtuse, slightly recurved; area depressed, covered with closely-set transverse striations divided by a feeble distinct median furrow, marginal carina gently curving and slightly raised, the inner carina shorter, escutcheon narrow and of small dimensions; surface ornamented with concentrically excavated, step-like costae, equally spaced and elevated; intercostal area furnished with numerous perpendicular clavate ridge bearing oblique striations.

In referring this species to the Clavellatae, NEWTON made its comparison with *Trigonia formosa*, *T. phillipsi* and *T. mountieriensis*

from the Lower Oolite in Europe. It looks to me more closely related to *Myophorella* (*Haidaia*) *crenulata* KOBAYASHI and TAMURA than any of these three LYCETT's. The Japanese species occurs in the *Lima* sandstone or the 5th Trigonian zone of Soma in Fukushima Pref., North Japan. As illustrated in fig. 11 for comparison, it disagrees with this only in the more inequilateral and taller outline and more anterior position of the umbo. Striation on the vertical crenules on the costae are occasionally seen in *crenulata*, but they are transversal, instead of oblique in *molengraffi*.

This species is represented by several specimens, but all smaller than *crenulata*. The largest is said 20 mm. by 20 mm. and the smallest example 15 mm. by 15 mm.

Occurrence:—Buduk (Boedoek), West Borneo.

Family Pectinidae

Genus *Chlamys* BOLTON MS., RÖDING

Chlamys sp. indt.

Plate III, figure 15.

A right valve 22 mm. high and 20 mm. long is moderately convex and ornamented with numerous radial ribs which are often bifurcated. The ears are not well preserved, but the anterior one is seen to have a deep byssal sinuation.

Occurrence:—Float on the Amagá river, Mindoro.

Subgenus *Radulopecten* ROLLIER

Chlamys (*Radulopecton*?) *villai* KOBAYASHI, new species

Plate III, figures 13–14.

Shell a little higher than long, subequilateral, slightly inequivalve; right valve nearly flat; left one gently convex; ventral margin almost semicircular; dorsal margins of the main body nearly straight, meet at the umbo, forming an angle of 90 degrees or a little less; anterior ear of right valve one and a half as long as posterior ear, provided with a deep byssal notch; its posterior ear subrectangular; each valve bearing 8 stout round radial ribs which are more or less obsolete near umbo; their intervals mostly broader than ribs; along dorsal margins there is a broad flat area on each

side which is somewhat undulate or may be provided with a slender median rib; concentric lines insignificant.

The right valve which is the holotype is 32 mm. in height and 29 mm. in length; left valve is almost the same size, but imperfectly preserved.

This is evidently not a typical *Chlamys*, but more likely an *Aequipecten* FISCHER, because the shell is slightly inequivalve and its outline fairly broad and well rounded; ribs stout and small in number.

In accepting the opinion of STAESCHE and ARKELL that the so-called Jurassic *Aequipectens* are not ancestral to the Cainozoic *Aequipecten*, COX (1952) adopted *Radulopecten* for the group of *Aequipecten fibrosus* SOWERBY by STAESCHE (1926). It was noted by STAESCHE that the right valve has stout sculptures in the group, while they are found in the opposite valve in the group of *A. varians*. In this species the strength of the ribs is nearly the same between the two valves.

As a characteristic of *Radulopecten*, COX pointed out the presence of imbricating concentric lamellae by which the ribs take squamose aspect, like most ribs of *Chlamys*. Such concentric markings are, however, not seen in the Philippine specimens. *Radulopecten* has flourished in Europe in the Middle and Late Jurassic period. *Chlamys* (*Radulopecten*) *moondanensis* COX is described from the Tithonian of Cutch, but the Philippine form is not diagnostic of the subgenus.

Occurrence:—Same as the preceding.

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T. Kobayashi

A Trigonian Faunule from Mindoro in the Philippine Islands

Plate III

Explanation of Plate III

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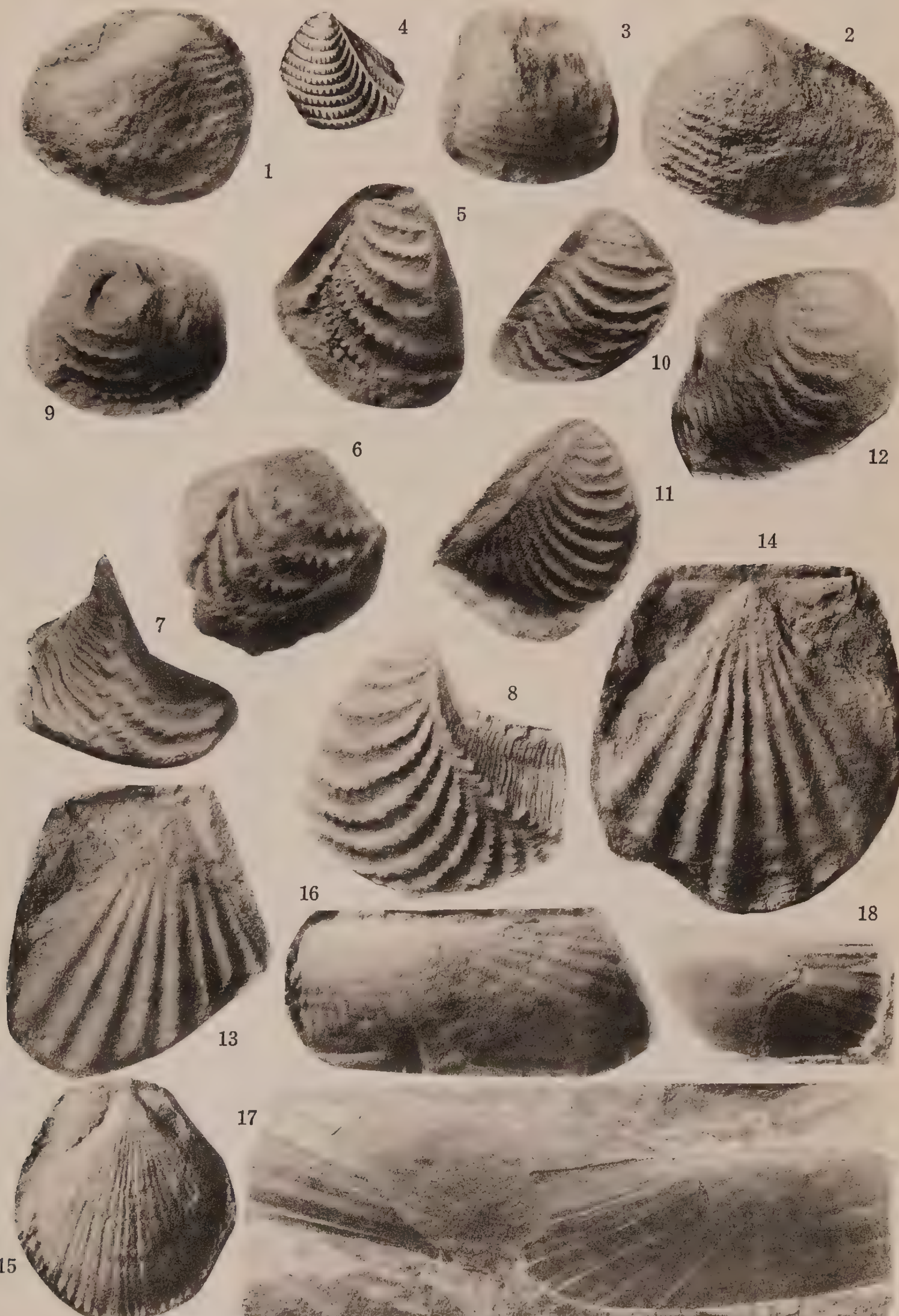
All of the illustrated specimens from Mindoro are in the Bureau of Mines at Manila, Philippines. Their replicas made from dental modeling are kept in the geological Institute, University of Tokyo. The specimen in fig. 8 belongs to the collection of the same institute. The replicas of *Solenomya* (*Acharax?*) *murotoensis* are also in the institute and their original specimens stored in the Kochi University.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Upper Cambrian Fossils from Peninsular Thailand*

By

Teiichi KOBAYASHI

With Two Plates

It is an important question in regional geology whether the Phuket series in the central and western parts of Peninsular Thailand is really Cambrian, because little is known of the Eo-Palaeozoic stratigraphy of this part of Asia. It consists of dark coloured pebbly shale, shale and fine-grained sandstone, but in many places they are metamorphosed into schist, slate, quartzite and argillite; pebbles are quartz, quartzite and medium grained biotite granite. Its thickness is estimated about 1,220 m. The Mergui series, or a part of it, in Lower Burma is presumed to be the possible equivalent of the Phuket series. Therefore it is possible that the series is the oldest sediments in the geosyncline in the stretch from the Shan plateau to Malaya.

Fucoidal impressions were found in a dark gray shale or slate of the Phuket series at the northeast promontory of Tengkhah harbour on Phuket island, on the west coast of Peninsular Thailand (BROWN et al., 1953). DUNCAN assigned them *Eophyton* (?) and called attention to the occurrence of *Planolites* (?) in the Cambrian of Yunnan (MANSUY, 1912). Were the problematicum really a Cambrian fossil, Phuket island is the southernmost locality of the Cambrian system in Eurasia, but this does require any undeniable fossil evidence for its decision.

On the occasion of the ECAFE** meeting held at Tokyo, in June, 1956, Mr. Saman BURAVAS, chief of the Geological Survey Division, Royal Department of Mines, Bangkok, brought me a small collection of Palaeozoic fossils for examination. Subsequently some

* Received Aug. 17, 1956; read at the 64th meeting of the Palaeontological Society of Japan at Kyoto, Oct. 6, 1956.

** Economic Commission for Asia and the Far East.

additional specimens were sent to me. He is so kind to donate them to the collection of our institute. They were procured in recent years from the Thai-Malaya borderland. I am happy to see in the collection that six slabs of sandstone contains a few genera of definitely late Cambrian in age. My cordial thanks are due to Mr. BURAVAS.

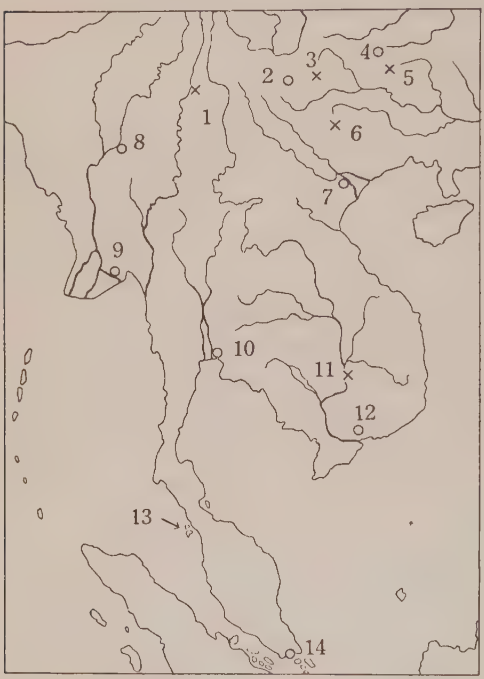

Fig. 1. Locality Map.

1. Paoshan (保山)
2. Kunming (昆明)
3. Chütsing (曲靖)
4. Kueiyang (貴陽)
5. Santu (三都)
6. Changpoung (長蓬)
7. Hanoi
8. Mandalay
9. Rangoon
10. Bangkok
11. Stung Treng
12. Saigon
13. Tarutao Island
14. Singapore

According to him this hard compact micaceous sandstone is exposed at various places on the west coast of Tarutao island. Its general trend is meridional. Stratigraphically, it lies below the Thungsong black limestone series which is considered Middle Ordovician, because *Actinoceras* sp. was found at Ron Phibun in association with bryozoans, crinoid stems and fragments of brachiopods.

In the sandstone slabs before hand there are fossils as follows:

Apheoorthis (?) sp.
Brachiopod, gen. et sp. indt.
Pagodia thaiensis KOBAYASHI, new species
Thailandium solum KOBAYASHI, new genus and species.

"*Eosaukia*" *buravasi* KOBAYASHI, new species
Saukiella tarutaoensis KOBAYASHI, new species
Coreanocephalus planulatus KOBAYASHI, new species
Opisthoparian free cheeks, gen. et sp. indt. (pl. II, fig. 11).
Agnostid, gen. et sp. indt.

The second form of the brachiopods which is not illustrated is represented by a fragmentary valve on slab 2. It is 12 mm. long, practically flat and ornamented with innumerable, very fine radial threads. This is evidently distinct in the surface sculpture, convexity and other aspects and larger than any specimen of *Apheoorthis* (?) sp. Although others are also not well preserved, *Pagodia*, *Saukiella* and *Coreanocephalus* warrant the late Cambrian age of the Tarutao faunule. *Coreanocephalus* was thought an endemic genus in South Korea. Its occurrence at Tarutao island shows the alliance of the fauna to that of the *Dictyites* zone in South Korea. *Saukiella* is a member of the Trempealeau fauna in the Upper Mississippi valley and rare in Asia. As discussed later, *Pagodia* is a leading genus in the late Upper Cambrian fauna of Eastern Asia. There are one Middle Cambrian (Taitzuan) species and several early Upper Cambrian ones of *Pagodia* which were described from South Manchuria, but their generic reference is doubtful. *Pagodia* is known from Liaotung, Shantung, Hopi and South Korea, but unknown from Central and South China or Yunnan-Tonkin borderland (KOBAYASHI, 1943).

It is a question whether *buravasi* belongs to *Eosaukia*, *Sinosaukia*, *Saukioides* or else. Nevertheless, saukids are all late Upper Cambrian trilobites with a sole exception of early Upper Cambrian *Eosaukia latilimbata* LU, 1954, from Kueichou. Specifically, *buravasi* looks similar to "*Tellerina*" *coreanica* KOBAYASHI, 1935, from the *Eoorthis* zone of South Korea on one side and to *Eosaukia* (?) *walcotti* (MANSUY) from the uppermost Upper Cambrian of the Changpoung series on the Yunnan-Tonkin border. Its associated pygidium is quite different from all of the Croixian saukids (ULRICH and RESSER, 1933), in the small size, broad outline and undeveloped marginal border.

In 1938 and 1944 I have noted the sea connection from South Korea to Northern Europe through Central China and Tienshan in the early Upper Cambrian period, as indicated by the distribution of *Hedinaspis*, *Proceratopyge* and a few Olenidian genera. This route

of migration was further confirmed by recent discoveries of *Proceratopyge* in Chekiang and Anhui and of the *Hedinaspis* faunule at Santa in Southeastern Kueichou. *Eosaukia latilimbata* is a member of the Santa faunule (LU, 1954).

The Changpoung series comprises several Upper Cambrian fossil zones, but bears no trilobites of the Olenidian province (MANSUY, 1915, '16, KOBAYASHI, 1944 B, '56). In East Yunnan the Gotlandian formation overlies the Lower and early Middle Cambrian unconformably (TING and WANG, 1937), the break indicating the land period of the southern projectile of the Tibetia.

According to SUN (1939), Upper Cambrian trilobites occur at some places in Paoshan (保山) district in West Yunnan. Namely, the Paoshan shale at Pupiao (蒲縹) yields the followings:

Agnostus cyclopyge TULLBERG
Quadraticephalus yunnanensis SUN
Saukia acamus (WALCOTT)
Saukia grabaui SUN
Tsinania sp.
Xenostegium sp.

Insofar as I can judge from the pygidia, the first species belongs most probably to *Pseudagnostus*. The relatively small eyes at about the mid-length of the cranidium reveal the alliance of *Quadraticephalus yunnanensis* with *Eosaukia* (?) *walcotti*. The pygidia of *Xenostegium* sp. may be combined with the cranidium of *Tsinania* sp. in a species. It is probable that the species thus figured out is related to *Dictyella* (?) *mansuyi* KOBAYASHI, 1933, i. e. *Illaenurus cere* by MANSUY, 1916.

In addition there are four fossil localities in West Yunnan (SUN and SZETU, 1947) as follows:

(1) *Calvinella walcotti* and *Conocephalina waltheri* from Taurahtsun (陶然村) and Sankousung (三棵松).
(2) *Shirakiella laticonvexa* and *Pseudagnostus* from Shahocheng (沙河廠).
(3) *Briscoia*, *Pseudagnostus* and *Dictyonema* at Yunchuanchieh (雲川街).

These fossil beds are all late Upper Cambrian. *Saukia* (*Briscoia* ?) *vagans* and *Prosaukia middlemissi* are described by REED (1934) from Kashmir, but their generic position is dubious. In view of *Saukia* and *Iranaspis* in Iran (KING, 1937), however, it can be ascertained that the Himalayan trough must have been the route of migration

for the saukids. The Cambrian faunule of Tarutao island testifies the southernmost point of this sea way. At the same time it is a link between the faunas of the age in Asia and Australia, because *Pagodia* and saukids were lately found in the Macdonnell ranges and the Huckitta-Marqua region in Northern Territory, Australia. (ÖPIK, 1956, CASEY and GILBERT-TOMLINSON, 1956).

Apheoorthis (?) sp.

Plate IV, Figures 1–4.

Shell subquadrate, broader than long, broadest at hinge margin which is a little alate at lateral ends, rounded along antero-lateral margin. Ventral valve fairly convex and provided with a small median sinus of moderate breadth; umbo only a little projected beyond hinge line; delthyrium seemingly open; pseudospondilium not well developed. Dorsal valve strongly convex. Surface marked by many fine ribs which increase their number by branching and form bundles.

Because the preservation is poor, one cannot go very far into taxonomy. Though superfacial, fasciculate ornamentation is suggestive of *Apheoorthis*, this species appears to be allied to "*Eoorthis*" *shakuotunensis* SUN, 1924, from South Korea (KOBAYASHI, 1935).

Genus *Pagodia* WALCOTT

1905 *Pagodia* WALCOTT, *Proc. U.S. Nat. Mus. Vol. 29*, p. 63.
1913 *Pagodia* WALCOTT, Cambrian Faunas of China, p. 160.
1933 *Pagodia* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 9*, p. 109.
1953 *Pagodia* HUPÉ, *Ann. de Paléontol. Tom. 39*, p. 181.

Genotype:—*Pagodia lotos* WALCOTT.

Remarks:—Broad, subtrapezoidal cranidium, oblong glabella with obsolete furrows at sides, small eyes at about mid-length, lack of palpebral ridges and subparallel or convergent anterior facial sutures are the characteristics of this genus. The associated pygidium is broad and has a conical segmented axis, narrow pleural lobes and smooth poorly defined marginal border.

In 1933 I have discussed the genus in detail. My comments on the occurrence of *Pagodia buda* RESSER and ENDO in the Fengshanian (or Yenchou), instead of the Changshanian (or Paishan) were later

accepted by ENDO (1937). I have here a plaster cast of the type cranidium of *Pagodia hemispherica*. Because its eyes are relatively large and located fairly back and eye ridges distinctly impressed on the cast, it looks closer to *Chuangia* than *Pagodia*.

In 1937 and 1944 ENDO described 11 new species and 1 new variety of *Pagodia*. *P. subquadrata* from the Taitzuan of Hsiaoshih which has a relatively narrow cranidium and a flat depressed frontal border is more likely a *Lisania* than a *Pagodia*. Among 6 Changshanian species, *P. perquadrata* having a striated frontal rim and *P. laohuensis* with distinct eye ridges belong probably to *Chuangia*. Three pairs of clear-cut lateral furrows on the conical glabella and strong eye-ridges are quite suggestive of *Kaolishania* for *P. trisulcatus*. The cranidium called *P. circularis convexa* looks to me so aberrant that together with *P. circularis* it represents an unnamed genus. *P. angustilimbata* possesses a cranidium and fixed cheeks too narrow for *Pagodia*. The illustration and description are inadequate to add any comment on *mina*. Nevertheless, I do not hesitate to say that none of them is safely referable to *Pagodia*.

Among Fengshanian species *paraquadrata* has the cranidium so closely allied to *P. richthofeni* that their difference is thought no more than variation within a species. If *P. convexa* is a *Pagodia*, the convexity of its cylindrical glabella is very unusual. The high triangular pygidium on which *P. triangulata* is founded, appears to me out of the bound of the genus.

Distribution:—Fengshanian or late Upper Cambrian; common in Liaotung and Shantung, but as yet unknown from the Taitzuho region, North Korea and Shansi basin. In Hopeh, South Korea and Peninsular Thailand the genus is represented respectively by *P. damesi*, *P. shumardoides* and *P. thaiensis*. *Pagodia* is reported to occur in the Kuznetsk basin, Siberia (YAVORSKY, 1937) and Northern Territory of Australia (ÖPIK, 1956, CASEY and GILBERT-TOMLINSON, 1956), although I have not yet seen either description or illustration.

Pagodia thaiensis KOBAYASHI, new species

Plate IV, Figures 5–7.

Description:—Cranidium subtrapezoidal, well rounded in front, as broad again as long, moderately convex, most elevated near the

center; glabella outlined by deep dorsal furrows, moderately convex, long, parallel-sided in anterior, but posterior half is gradually expanding backward; anterior lateral furrows very short or absent, while middle and posterior ones are quite pronounced, more or less oblique and disconnected on axis; occipital furrow transversal; occipital ring narrower than lateral lobes; eye medium in size and located a little anterior to middle length; eye-ridge indiscernible; fixed cheek expanded behind the eyes as far as its breadth, becomes subequal to glabella; frontal limb absent; frontal rim wire-like and strongly arcuate; facial sutures parallel to each other, anterior to eyes and diagonal posterior to them.

Measurements and observation:—The holotype cranidium (fig. 6) is about 4.5 mm. long and 7 mm. broad; paratype (fig. 5) about 4 mm. long.

Oxidation renders difficult to judge the original texture of the carapace, but at least it can be said that there is no distinct granulation on the cranidia. Close to the paratype there is an outer mould of a small pygidium (fig. 7) which belongs possibly to this species. It is nearly semicircular and slightly inflated except a narrow axial lobe which is elevated above the gently inclined plerual lobes. The axis is teretely conical and abruptly narrows near the posterior end. Surface is seemingly non-granulose.

Comparison:—This resembles *P. bia*, *P. damesi* and *P. buda*, but the glabella is scarcely contracted at the middle portion. In the fairly anterior position of the eyes, it disagrees with all of the genus so far known.

Genus *Thailandium* KOBAYASHI, new genus

The truncato-conical glabella, medium sized eyes at the mid-length of the cranidium subparallel anterior sutures which are intramarginal on the border, and puacisegmented pygidium are distinguishing characters from resembling genera of the Anomocarinae and Elvininae. Further notes are given in the description of the type species, *T. solum*.

Thailandium solum KOBAYASHI, new gen. and sp.

Plate IV, Figures 9–12; Text-figure 2.

Description:—Cephalon large and semicircular in outline, if genal spines are excluded; glabella slightly convex, a little elevated above flat fixed cheeks which are about half as broad as glabella at eyes; first and second lateral furrows short and rudimentary; third furrow a little oblique and joins its counter on axis; eyes of moderate size, located a little posterior to mid-length of cranidium; eye-ridge insignificant; frontal rim and limb equal in length where the former is elevated above the latter, narrowing posteriorly and produced into a long genal spine; facial sutures slightly convergent in front of eyes, abruptly cut into border and extended far inward; posterior suture nearly diagonal except for terminal part where it becomes subvertical and cuts posterior margin at some distance from genal spine.

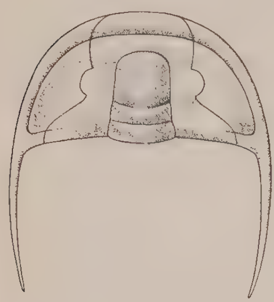

Fig. 2. *Thailandium solum* KOBAYASHI, new genus and species.

The pygidium referred to this species is lenticular in outline, the anterior margin being less convex than the other, twice as broad as long; axial lobe teretely conical, convex, composed of 4 rings and a relatively long terminal lobe, ending on the inner margin of the posterior border where it is rounded off; pleural lobe gently convex, inclined gradually in the outer side; facet delimited by a strong ridge which extends as far as the lateral margin; four pleural ribs behind it flat-topped, separated from one another by plerural furrows; interpleural furrows discernible only under cross light; these ribs and furrows truncated by a fairly thick marginal border; marginal furrow narrow and distinct.

Test smooth.

Observation and comparison:—In the exfoliated part of a pygidium (fig. 12) the doublure is seen twice broader than the marginal border.

This cranidium is similar to that of *Elvinia* WALCOTT, 1924, but the glabella is more conical, eye-ridge stronger, frontal limb and fixed cheek are larger and anterior sutures divergent in that genus.

This species agrees with *Annamitia spinifera* MANSUY, 1916, in the course of the facial suture and several other features, but the glabella is much larger, free cheek smooth, the posterior margin of the cephalon straight and the nuchal spine absent. Furthermore, eyes are smaller and eye-ridges effaced in this species.

Compared to "*Anomocare*" *flava* WALCOTT, furrows on the glabella are not so much obsolete, eyes smaller, and anterior facial sutures by no means divergent in this species. The pygidium has one or two segments less in number than WALCOTT's.

Genus *Eosaukia* LU

1954 *Eosaukia* LU, *Acta Pal. Sinica, vol. 2, No. 2,* p. 144.

Type species:—*Eosaukia latilimbata* LU. (Text-fig. 3).

Remarks:—The genus is represented by monotypic *latilimbata* which was established on the basis of a sole but complete shield. This species bears special importance not only because of its older age than all other saukids, but also because of possession of 11 thoracic segments and broad semi-circular pygidium. In *Saukia acuta* ULRICH and RESSER as well as *Tellerina crassimarginata* (WHITFIELD) the thorax is known to have 12 segments. In the typical Saukinae the pygidium is longer, well rounded and multisegmented; pleural and interpleural furrows are often well marked. The latter is, however, effaced in *E. latilimbata*. This pygidium better agrees with those of *Asioptychaspis* and *Quadraticephalus* in outline and segmentation, although their cephala are different. The eyes are smaller and located far anteriorly and the glabella is commonly drooping in the Ptychaspinae.

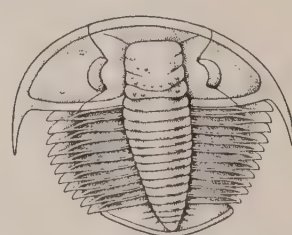

Fig. 3.
Eosaukia latilimbata LU.

Calvinella (?) *walcotti* (MANSUY), *Sinosaukia pustulosa* SUN, *Saukioides jeholensis* (KOBAYASHI), "*Prosaukia*" *brizo* (WALCOTT), "*Saukia*" *iranicus* (KING) and a few other Asiatic saukids have small but relatively broad paucisegmented pygidia, insofar as can be judged from their association with the cranidia. Therefore it is a question whether they are congeneric with the Croixian species.

The effacement of interpleural furrows varies among them. They are clearly seen in *brizo* and *iranicus*, but indiscernible in *walcotti* (KOBAYASHI, 1956).

Distribution:—Early Upper Cambrian of Yangtze basin. At Santu, Kueichou, the type species is found associated with *Lotagnostus*, *Hedinaspis* and *Charchaqia*.

"*Eosaukia*" *buravasi* KOBAYASHI, new species

Plate V, Figures 1–10, 13–20.

Description:—Cranidium strongly inflated; glabella surrounded by deep dorsal furrows, strongly convex, highly elevated above cheeks, abruptly slant forward, one and half times as long as broad, slowly expanding in posterior; anterior and middle lateral furrows rudimentary; posterior one well developed, oblique and confluent with its fellow on axis; occipital furrow transversal; occipital ring of uniform thickness, devoid of median spine; eye fairly large, longer than a third the length of cranidium; fixed cheek most elevated at eye where it is narrower than a half of glabella, but its posterior limb is widely dilated laterally; eye-ridge absent; frontal border as thick as anterior fixed cheek, delimited on two sides by divergent furrows and separated from glabella by a deep frontal groove; anterior facial sutures parallel to axis and posterior ones diagonal. Free cheek convex; ocular platform surrounded by pronounced depression and then convex border which is in turn produced into a genal spine.

Pygidium sublenticular; anterior margin broadly arcuate; the other margin more strongly rounded and nearly straight or somewhat sinuate behind axial lobe. This lobe outlined by deep furrows on lateral sides, strongly convex, elevated above pleural lobes, composed of three rings and small terminal lobe which are distinctly separated by furrows from one another; pleural lobe fairly well inflated; two or three furrows well seen on the lobe near axis; marginal border very narrow and depressed.

Measurement:—The holotype cranidium (fig. 5) is 15 mm. long and 23 mm. and about 16 mm. broad respectively at the base and between the eyes; glabella is 13 mm. long and 9 mm. broad. The pygidium (fig. 17) is 8.5 mm. long and 20 mm. broad; its axial lobe 6.3 mm.

at the broad anterior end.

Observation:—It is interesting to see the increase of the frontal drooping through growth. It can be clearly recognized by comparison between small cranidia (figs. 1–2) and large ones (figs. 18–20). Those in figs. 3–5 are intermediate in size as well as in degree of drooping.

Due to the drooping the lateral border of the free cheek is bent and extended forward and downward in the grown form (fig. 14). It is certainly a remarkable fact that 6 or more radial ridges are seen on the internal moulds which cross the lateral border near the genal angle (figs. 8–9). They are vertical lamellae similar to those of *Symphysurina woosteri* ULRICH.

The test of the carapace is granulated, as recognizable on some external moulds of cranidia and free cheeks, but furrows are generally smooth (figs. 6–7). Some external moulds are rough, but not granulated. It is difficult to say without more material, whether they are water-worn, or whether they belong to a non-granulate form.

A thoracic segment (fig. 10) has a strongly convex axial ring. It is separated from the articulating half-ring by a deep furrow. Its pleuron is a little wider than the ring and divided into two ribs by a deep furrow. Like the cephalon the elevations are granulated and depressions smooth.

Comparison:—The essential distinction of this species from *Eosaukia latilimbata* lies in the shorter glabella, much larger preglabellar area and well developed eyes which are located more posteriorly in that species. Further, it is said that the ocular platform is marked by inosculating concentric raised lines around the eye, but such markings are not seen in this species.

This is closely allied to *Sinosaukia pustulosa* SUN, as revealed by the similarity of most features of the cranidium and free cheek. It is stated by SUN, however, that in his species the frontal brim is rather broad, smooth, flat or slightly concave and ill-defined or indistinctly separated from a narrow frontal edge ornamentated with *a single row of large pustules at the margin*. The associated pygidium is much longer, multisegmented and not pustulated, although its reference to *S. pustulosa* is not warranted.

Eosaukia (?) *walcotti* (MANSUY) has also the granulose test and

similar outline as the present species, but the frontal drooping is negligible in that species even in the grown stage. The cranidium and glabella are strongly drooping in "*Tellerina*" *coreanica* KOBAYASHI. This agrees with the present species in many features of the cephalon, but the test appears smooth in the Korean species. It is probable that they are congeneric. In the Korean species the associated pygidium is subtriangular and long, but its asymmetrical outline shows that the secondary deformation is strong.

Tellerina chinhsiensis (SUN) has the smooth test. It is similar to *T. coreanica* in the cranidium, but the frontal drooping is insignificant even in the adult stage. The associated pygidium is typical of the Saukinae in that species.

The test is also smooth in *Saukioides suni* which is again different from the present species in the median thickening of the occipital ring, broader fixed cheek, a little smaller eyes, fairly thick frontal border and insignificant diagonal furrows on the marginal border.

Saukiella tarutaoensis KOBAYASHI, new species

Plate V, Figure 12.

Represented by a cranidium, 12.2 mm. long and 12.8 mm. broad at eyes. Glabella 10.3 mm. long, 6.5 and 8.6 mm. wide respectively at the anterior and posterior end, large, subquadrate and moderately inflated. Anterior and middle furrows short and weak; posterior and occipital ones strong and persistent through glabella, where the latter is nearly straight and the former arcuate. Fixed cheek very narrow; eye large, located at mid-length of cranidium. Frontal border separated from glabella by a straight furrow. Facial sutures nearly parallel to each other in front of eyes and intramarginal on border. Test smooth.

Compared to *Saukiella typicalis* ULRICH and RESSER and other American species, the eyes are smaller and their position is not so posterior. Otherwise this is typical of *Saukiella*. In the low inflation of the cranidium and its anterior outline this is quite different from *Saukiella* (?) *paiensis* RESSER and ENDO.

Genus *Coreanocephalus* KOBAYASHI

Coreanocephalus planulatus KOBAYASHI, new species

Plate IV, Figures 13–17; Text-figure 4.

Description:—Cephalon semicircular, but long genal spines are present; glabella outlined by dorsal furrows, truncato-conical, somewhat more expanded in posterior, gently inflated; posterior and occipital furrows discernible; eyes of medium size, close-set to anterior of glabella; preglabellar area simple; facial sutures slightly divergent forward from eyes and then marginal; their posterior branches diagonal.

The pygidium which may go with the cephalon is long, ovate; axial lobe short, prominent, conical, abruptly narrowing in posterior whence a narrow ridge issues; another three rings well marked by furrows; pleural lobe gently convex, merges with broad, slightly concave border; an anterior ridge subangulate on top; two pleural bands behind it bisected by a short interpleural furrow; fussion advanced in posterior.

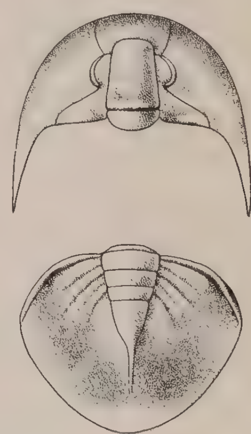

Fig. 4. *Coreanocephalus planulatus* KOBAYASHI, new species.

Observation and comparison:—Insofar as the cranidium is concerned, this species is closely allied to *Coreanocephalus kogenensis* KOBAYASHI, 1935, but in that species the eyes are larger and located more posteriorly and middle and posterior furrows poorly impressed on the glabella form two Vs. *Dikelocephalites flabelliforme* SUN, 1935, having two pairs of pits on the glabella and a well expanded preglabellar area is more distant.

In the exfoliated pygidium the doublure is seen to be considerably broadened from the lateral to the posterior part. The elongately ovate outline and notably the dilation of the rear part are characteristics which discriminate this pygidium from those of *Briscoia*, *Walcottaspis*, *Dikelocephalites* and most other dikelocephaloids.

Agnostid, gen. et sp. indet.

Plate IV, Figure 8.

A cephalon strongly convex, highly elevated, surrounded by a broad flange on anterior and lateral side where on the latter, however, soon it narrows backward; posterior margin straight. The glabella is so much obsolete that its outline and segmentation can hardly be figured out. But their obscurity may depend on erosion to a great extent. It is impossible to say any further than an agnostidian cephalon for this specimen.

List of the Upper Cambrian Fossils from Peninsular Thailand

Slab Number	1	2	3	4	5	6
Apheoorthis (?) sp.	×		×		×	×
Brachiopod, gen. et sp. indt.		×				
Pagodia thaiensis, cranidium	×		×			
Ditto. pygidium	×					
Thailandium solum, cranidium						×
Ditto. free cheek						×
Ditto. (?), pygidium			×	×		
"*Eosaukia*" *buravasi*, cranidium	×	×	×		×	×
Ditto. free cheek	×			×	×	×
Ditto. thoracic segment	×					
Ditto. pygidium	×			×		×
Saukiella tarutaoensis, cranidium					×	
Coreanocephalus planulatus, cranidium						×
Ditto. free cheek		×		×		
Ditto. pygidium				×		×
Opisthoparian free cheeks, gen. et sp. indt.,	×					
Agnostid, gen. et sp. indt.						×

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T. KOBAYASHI

Upper Cambrian Fossils from Peninsular Thailand

Plate IV

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"Pseudosepta" are also seen in the Schizocoralla OKULITCH which include three orders, Tetradina, Heliolitina and Chaetetina. *Tetradium* has as a rule only four pseudosepta, and according to OKULITCH (1935) asexual reproduction is their main function. Therefore these pseudosepta are different from those of the chain corals.

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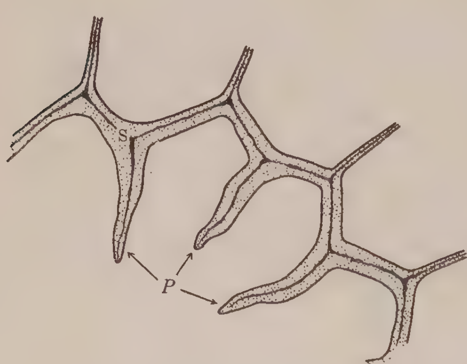

Text-fig. 1. Wall structure of *Heliolites interstinctus* L. from Gotland Isl. (after WEISSERMEL, 1898)
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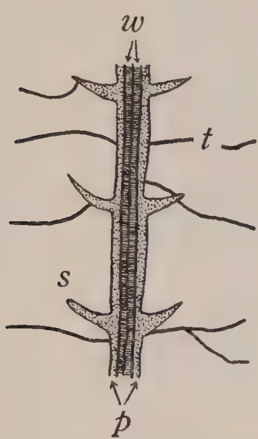
similar to the Halysitidae and especially to *Halysites* in the dimorphic corallites and twelve rows of septal projections, but the observations about the septal structures of the Heliolitida by BOURNE and others lead one to conclude that the projections are genetically different from the septal spinules of the Halysitidae.

Wall structure of *Favosites* was clarified by SWANN (1947) with many excellent illustrations. His plates show that the septal projection of *Favosites alpenensis* seems to be made of the same stereoplasmic deposits of the peripheral stereozone (Text-fig. 2). It is



Text-fig. 2. A longitudinal section of *Favosites alpenensis peninsulae* showing its wall and septal structures. *p*: peripheral stereozone, *s*: septal spines, *t*: tabulae, *w*: primary wall.

Schematized from SWANN's figure 6 on plate 7 (1947).

Text-fig. 3. A cross section of *Favosites forbesi* var. *eifeliensis* showing its linguiform pseudosepta.

From LECOMPTE's fig. 1, p. 502, (1952) after NICHOLSON.

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In conclusion it can be said that the septal spinule of the

* DUNCAN, H. (1956) treats the group as subgenus of *Favosites*.

Explanation of Plate IV

Apheoorthis (?) sp. .... p. 371

Fig. 1. Ventral valve, clay-cast, ×2, slab 1.

Fig. 2. Ventral valve, ×1.5, slab 5.

Fig. 3. Ventral valve, internal mould, ×1.5, slab 6.

Fig. 4. Dorsal valve, ×1.5, slab 5.

Pagodia thaiensis KOBAYASHI, new species .... p. 372

Fig. 5. Paratype cranidium, ×3, slab 1.

Fig. 6. Holotype cranidium, ×3, slab 3.

Fig. 7. Associated pygidium, clay-cast, ×3, slab 1.

Agnostid, gen. et sp. indt. .... p. 380

Fig. 8. Cephalon, ×3, slab 6.

Thailandium solum KOBAYASHI, new gen. and sp. .... p. 374

Fig. 9. Holotype cranidium, ×1, slab 6.

Fig. 10. Paratype free cheek, ×1, slab 6.

(?) *Thailandium solum* KOBAYASHI, new gen. and sp. .... p. 374

Fig. 11. Pygidium, ×1.5, slab 4.

Fig. 12. Pygidium, ×1, slab 3.

Coreanocephalus planulatus KOBAYASHI, new species .... p. 379

Fig. 13. Holotype cranidium, clay-cast, ×1, slab 6.

Fig. 14. Paratype cranidium, ×1, slab 6.

Fig. 15. Free cheek, ×1, slab 2.

Fig. 16. Pygidium, clay-cast, ×1, slab 6.

Fig. 17. Pygidium, partly exfoliated, ×1, slab 6.

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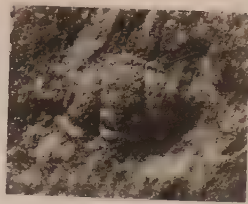

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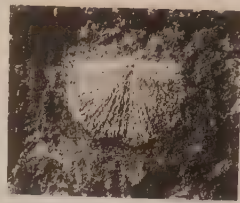

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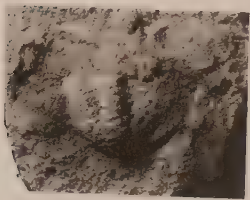

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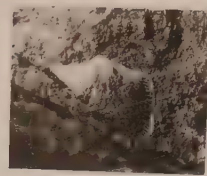

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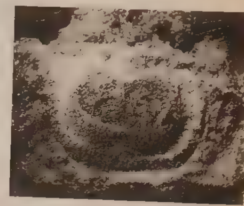

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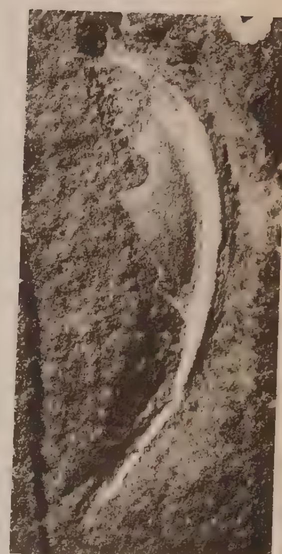

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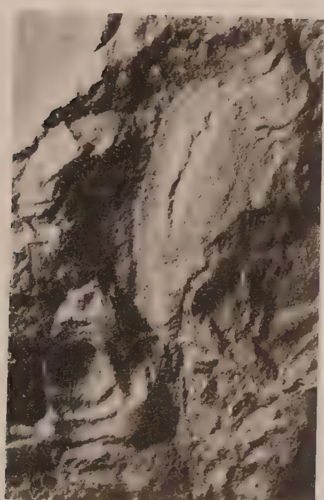

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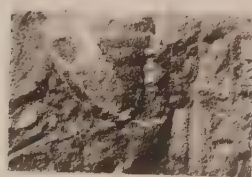

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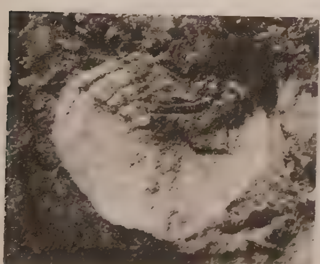

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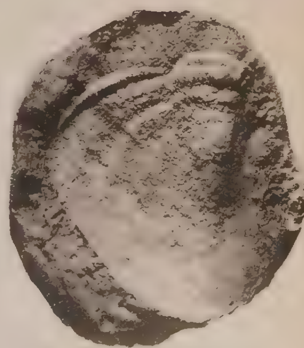

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T. KOBAYASHI

Upper Cambrian Fossils from Peninsular Thailand

Plate V

Explanation of Plate V

"*Eosaukia*" *buravasi* KOBAYASHI, new species ....p. 376

Fig. 1. Small cranidium, clay-cast, ×3, slab 3.

Eig. 2. Small cranidium, ×3, slab 3.

Fig. 3. Cranidium, ×2, slab 6.

Fig. 4. Cranidium, ×1.5, slab 6.

Fig. 5. Holotype cranidium, ×1, slab 5.

Fig. 6. Cranidium, clay-cast showing texture, ×1, slab 6.

Fig. 7. Free cheek, clay-cast showing a profound marginal groove and granulated text, ×2, slab 5.

Fig. 8. Free cheek showing internal lamellae, ×1, slab 5.

Fig. 9. Free cheek showing internal lamellae, ×1.5, slab 6.

Fig. 10. Thoracic segment, clay-cast, ×1.5, slab 1.

Opisthoparian free cheeks, gen. et sp. indt..p. 369

Fig. 11. Two free cheeks, ×1.5, slab 1.

Saukiella tarutaoensis KOBAYASHI, new species..p. 378

Fig. 12. Cranidium, ×1, slab 5.

"*Eosaukia*" *buravasi* KOBAYASHI, new species ....p. 376

Fig. 13. Free cheek, ×1.5, slab 1.

Fig. 14. Free cheek, ×1.5, slab 5.

Fig. 15. Free cheek, ×1.5, slab 1.

Fig. 16. Small pygidium, ×2, slab 4.

Fig. 17. Paratype pygidium, ×1.5, slab 4.

Fig. 18. Full grown cranidium, ×2, slab 2.

Fig. 19–20. Upper and obliquely lateral views of a full grown cranidium, ×1.5, slab 6.


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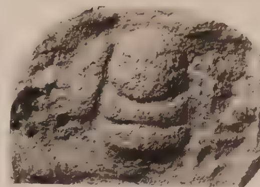
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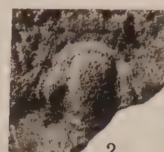
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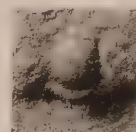
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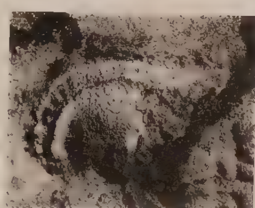
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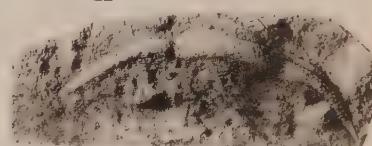
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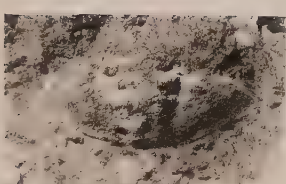
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20

On the Septal Projection of the Halysitidae

By

Takashi HAMADA

With one Plate

Introduction

Septal projection is one of the most remarkable features for some chain corals, bearing great importance to compare the Halysitidae with other Anthozoa. Two main questions are, however, attached with the septal projection. One is whether the septal projection of the Halysitidae are homologous or analogous with those of other corals. The other is whether they can be applied to the taxonomic distinction in the family. An attempt is made in this paper to solve the problems.

The writer wishes to express his thanks to Professor Teiichi KOBAYASHI of the Geological Institute, University of Tôkyô for suggesting this investigation as well as for constant guidance in the course of the work, and to Dr. Hisakatsu YABE for his invaluable advice and criticism.

What is the septal projection of the Halysitidae?

Some previous workers have already discussed the problem. Emphasizing the presence of septal spinules* in about twelve rows in the corallites, GÜRICH (1908) referred the chain corals tentatively to the Hexacoralla. This reference is, however, as OKULITCH (1936) has pointed out already, out of discussion because of the septal development and chronological position of the Hexacoralla. The Tetracoralla differ also from the Halysitidae in the arrangement and structure of their septa. Acanthine septa of rugose corals

* Here 'septal spinule' is used for the 'septal spine' of the Halysitidae.

have been well studied by HILL (1936). Her description leads the writer to convince that the structures are different distinctly from those of the Halysitidae, though some acanthine septa are apparently similar to them in the arrangement at the inner surface of corallite wall. In short, the septal projection of the Halysitidae is unique among corals, and the septal spinule belongs to a kind of "pseudosepta".

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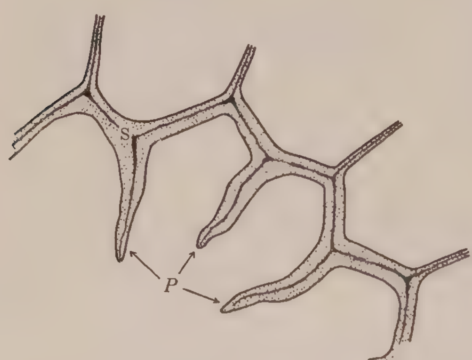

Text-fig. 1. Wall structure of *Heliolites interstinctus* L. from Gotland Isl. (after WEISSERMEL, 1898)
S: "Primärstreif"
P: Pseudosepta

It is quite improbable that the septal spinules of the Halysitidae are similar remnants because the Halysitidae have no "syphonopores" around the "autocorallites", although "mesocorallites" are found between two autocorallites of *Halysites*. The Heliolitida look

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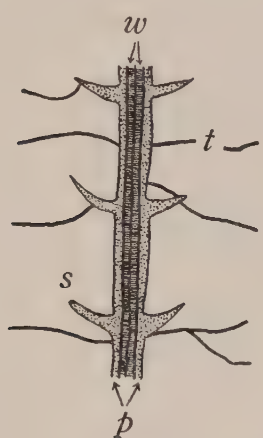
Wall structure of *Favosites* was clarified by SWANN (1947) with many excellent illustrations. His plates show that the septal projection of *Favosites alpenensis* seems to be made of the same stereoplasmic deposits of the peripheral stereozone (Text-fig. 2). It is



Text-fig. 2. A longitudinal section of *Favosites alpenensis peninsulae* showing its wall and septal structures. *p*: peripheral stereozone, *s*: septal spines, *t*: tabulae, *w*: primary wall.

Schematized from SWANN's figure 6 on plate 7 (1947).

Text-fig. 3. A cross section of *Favosites forbesi* var. *eifeliensis* showing its linguiform pseudosepta.

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* DUNCAN, H. (1956) treats the group as subgenus of *Favosites*.

Scheme of a classification of the Halysitidae*

Family Halysitidae M. EDWARDS & HAIME, 1850

nom. transl. DUNCAN, 1872 (ex Halysitinae M. EDWARDS & HAIME, 1850). (After HILL, D. & STUMM, E.C., 1956, p. 469)

Diagnosis:—Tabulate corals with coralla built up of cylindrical corallite tubules which anastomose to make chains and fenestrules in cross section. The shape of the corallum is variable,—massive, semispherical, bunshape, ramose, etc.—according to their reticulations of the corallites the shape of which is also indefinite. The corallites are round, elliptical, oval, etc. in cross section. In some groups they are monomorphic within a corallum; in others there are two forms of corallites, large (autocorallites) and small (mesocorallites) in size. Corallite tubules are crossed by horizontal or curved tabulae which are typically complete. They comprise series of corallites with catenous arrangement in general, but sometimes appear compact coralla, and isolated corallites.

In some group septal spinules are present in corallite, and it makes a pseudocolumella at the center of the corallite in a few species. Corallite walls are composed of epitheca, midwall and peripheral stereozone. Mural pores are entirely absent.

Remarks:—Some 90 specific and varietal names are known but a part of them may be invalidated by synonymy. They are attempted here to classify into three subfamilies and nine genera.

Distribution:—World-wide but not reported from South America, Antarctica and Africa?**; from lower Middle Ordovician to Upper Gotlandian, and Lowest Devonian?

Key to the Halysitidae

I) Without mesocorallites .... Subfamily Cateniporinae
  1) Without septal spinules
    a) Angular corallites.. Genus *Labyrinthites*
    b) Occasionally with isolated cotallites........................ Genus *Eocatenipora*
    c) Ordinary chain of not angular corallites........................ Genus *Quepora*
  2) With septal spinules

* SOKOLOV (1956) erected an order Halysitacea.

** HILL & STUMM (1956, p. 469) cited Africa as one of the localities of *Halysites*.

a) Ordinary chain of corallites.. Genus *Catenipora*

II) With mesocorallites in a part but without in another in a corallum .... Subfamily Schedohalysitinae

a) With mesocorallites in a part but without in another in a corallum .... Genus *Schedohalysites*

III) With mesocorallites .... Subfamily Halysitinae

1) Without septal spinules

a) Mesocorallites with complete tabulae .... Genus *Halysites*

b) Mesocorallites with dissepiment-like incomplete tabulae .... Genus *Cystihalysites*

2) With septal spinules

a) Ordinary chain of corallites .... Genus *Acanthohalysites*

b) Compact junction of corallites making very small lacunae between them .... Genus *Densoporites*

Subfamily Cateniporinae, nov.

Diagnosis:—Halysitidae without mesocorallites in a corallum.

Distribution:—From Middle Ordovician to Upper Gotlandian.

Remarks:—TCHERNYCHEV (1941) established *Palaeohalysites* on the basis of '*Halysites gotlandicus* YABE', but his generic diagnosis coincides with the Cateniporinae to which *Catenipora* belongs.

Genus *Labyrinthites* LAMBE, 1906

Diagnosis:—Corallum massive, composed of slender, straight, upright corallites with numerous interspaces; corallites very small, quadrangular or five or six sided in transverse section; walls rather thick; tabulae thin, flat, and transversely cross the corallites.

Genotype:—*Labyrinthites chidlensis* LAMBE, 1906, *Cruise of the "Neptune" App. 4*, p. 324.

Remarks:—Though LAMBE's description suggests that the coral is a distinct genus, it is a question whether it belongs really to the Halysitidae, because the corallites differes greatly in shape and size from any preceding species of chain corals. LECOMPTE (in PIVETEAU, 1952) and HILL and STUMM (1956) accepted provisionally as a genus of the Halysitidae, as did LAMBE.

There are some resemblances to "*Tetrapora*" or *Hayasakaia* especially in the shape of the corallites, though this is the Permian genus in China and Indochina. An intensive study is required and the writer accepts it temporarily as a member of the Haly-

sitidae. *L.* (?) *monticuliporoides* and its varietal form *minor* by TROEDSSON (1929) clearly belong to the Syringoporidae.

Distribution:—Only an Ordovician species *Labyrinthites chidlensis* have been reported from Canada.

Genus *Eocatenipora*, nov.

Diagnosis:—Massive colonies of a small form of halysitid coral; fenestrules very fine; corallites cylindrical, well rounded in cross section, barely in contact, or even free; tabulae complete, fairly thick.

Genotype:—*Halysites cylindricus*, WILSON, 1926, *Canada Dept. Mines, Mus. Bull. 44*, p. 15, Pl. II, figs. 6, 7. National Museum of Canada No. 6736.

Remarks:—WILSON's fig. 6, Pl. II clearly shows "loose contact of the corallites" typical of the genus. *Halysites nicholsoni* KIAER (1929), from the Ordovician upper Vikenes formation at Stord, Norway is almost identical with the type species except for its larger corallites and occasional appearances of strongly bent tabulae. Though they do not make complete lacunae in some part, most chains of corallites with numerous tabulae warrant their being the Halysitidae and their loose contact is unique and to be an important clue to the asexual propagation and the origin of chain corals as BUEHLER (1955) noted on *E. cylindricus*.

This genus is very closely related to *Quepora* in primitive corallites without mesocorallites and septal spinules and occurrences in the Ordovician, though the latter lasted till the Gotlandian.

Distribution:—British Columbia, Canada and Stord, Norway; Upper (?) Ordovician.

Genus *Quepora* SINCLAIR, 1955

SINCLAIR, G. W., 1955, *Trans. Roy. Soc. Canada, Vol. 49, Ser. 3, Sect. 4*, p. 96.

Diagnosis:—Cateniporinae with normal series of corallites but without septal spinules.

Genotype:—*Halysites catenularia* var. *Quebecensis* LAMBE, 1900, *Geol. Surv. Canada, Contr. Canadian Paleont., Vol. 4, Pt. 1*, p. 69, Pl. IV, figs. 1, 1a, 1b.

Lectotype (chosen by BUEHLER, 1955) *:—Catenipora quebecensis* (LAMBE), GSC 11305, W. MCOUET and Jno. LEITCH, collectors.

Remarks:—BUEHLER (1955) has observed SINCLAIR's halysitid coral specimen from the Middle Ordovician formation at Ste. Anne de Chicoutimi, near the type locality of '*Halysites*' *catenularia* var. *quebecensis*, Lake St. John area, P. Q., Canada and designated the species as *Catenipora*. Subsequently, SINCLAIR (1955) erected a genus *Quepora* based upon BUEHLER's lectotype emphasizing that the species is devoid of mesocorallites and septal spinules or other longitudinal structures.

Judging from literatures this genus includes the following species of chain corals:—

1) *Quepora parallelus* (SCHMIDT), 1861, Lyckholm & Borkholm
2) *Q. pulchelus* (WILSON), 1926, Richmond
3) *Q. delicatulus* (WILSON), 1926, Richmond
4) *Q. sapporiensis* (OZAKI), 1934, Gotlandian?
5) *Q. sindoensis* (OZAKI), 1934, Gotlandian?
6) '*Halysites escharoides* FISCHER-BENZON' by OZAKI, 1934, Gotlandian?
7) *Quepora aequabilis* (TEICHERT), 1937, Trenton?
8) *Q. huronensis* (TEICHERT), 1937, Gotlandian
9) *Q. rasmusseni* (TEICHERT), 1937, Gotlandian

Halysites feildeni (ETHERIDGE) (1878), *H. simplex* LAMBE (1899) and some others may belong to the genus, though their descriptions are insufficient for exact comparisons.

Because the above mentioned species 4, 5 and 6 are from the pebbles in the Ken-niho (兼二浦, Kyŏmi-p'o) limestone-conglomerate at the base of the older Mesozoic Daido Series in Korea, their age is indefinite, although OZAKI has taken them for Gotlandian species. 1, 2, 3 and 7 are all from the Ordovician and *Quepora quebecensis* (BUEHLER) is a Middle Ordovician species. Only the last two are Gotlandian.

Distribution:—Mostly from Ordovician and some from Gotlandian.

Genus *Catenipora* LAMARCK, 1816

Diagnosis:—Cateniporinae comprise the corallum with moniliform ranks of corallites, and with septal spinules.

Genotype:—Catenipora escharoides LAMARCK, 1816, *Histoire naturelle des Animaux sans Vertébres*, p. 207.

Neotype (chosen by THOMAS and SMITH, 1954):—Specimen No. 4 of BROMELL collection in Paleontologiska Institution, Uppsala, Sweden, described and figured by BROMELL, 1728, p. 412, no. 7, and fig. on p. 412.

Remarks:—The genus can be divided into two groups. Namely, one is *Catenipora* with pseudocolumella (Group A) and the other without them (Group B). For example,

Group A......With pseudocolumella

1) *Catenipora elegans* FISCHER-BENZON	Got.
2) *C. microporus* WHITFIELD	M. Got.
3) *C. quadrata* FISCHER-BENZON	Got.
4) *C. escharoides* LAMARCK	Got.?

Group B ......Without pseudocolumella

Group B_1......With strong septal spinules

5) *Catenipora borealis* (WILSON)*	U. Ord.
6) *C. jacovikii* FISCHER VON WALDHEIM	Got.
7) *C. obliqua* FISCHER-BENZON	Got.
8) *C. parallelus* (YABE)	M.? Got.
9) *C. rubra* SINCLAIR and BOLTON**	U. Ord.

Group B_2......With reduced septal spinules

10) *C. hillae*, n. sp.***	Got.
11) *C. chillagoensis* (ETHERIDGE)	Got.
12) *C. gotlandicus* (YABE)	M. Got.
13) *C. minimus* (TCHERNYCHEV)	Got.
14) *C. robustus* (WILSON)	U. Ord.

As shown in the list, the group B is divided again into two subgroups. More precisely, *Catenipora* with well developed septal spinules (Group B_1) and with reduced ones which often absent in some part of corallites (Group B_2).

This subdivision is, however, not always practical, especially for ill-preserved specimens, because minor differences in the development of the septal spinules are easily misled by the observer. See discussion on the septal spinule in the preceding paper by the present writer.

Distribution:—From Upper Ordovician to Upper Gotlandian, and probably flourished during the Middle Gotlandian period. *Catenipora*

* Reported as *Halysites gracilis* var. *borealis* WILSON, 1931.

** See SINCLAIR and BOLTON (1956), pp. 203, 204.

*** *Halysites* sp. cf. *australis* ETHERIDGE by HILL, 1954, p. 39, pl. IV, figs. 8a, b.

elegans, and *C. escharoides* are widely distributed in Europe and western Siberia. In North America *Catenipora microporus* is common in the Niagaran. In Asia, there is no *Catenipora* with pseudocolumella, or the Group A.

Subfamily Schedohalysitinae, nov.

Diagnosis:—Intermediate Halysitidae of monomorphic and dimorphic types or chain corals with mesocorallites in places but without them in others within a corallum.

Distribution:—These forms are distributed in the Gotlandian of Asia and Australia.

Genus *Schedohalysites*, nov.

Diagnosis:—See the diagnosis for the subfamily.

Genotype:—Halysites orthopteroides ETHERIDGE, 1904, *Mem. Geol. Surv. New South Wales, Paleontology, No. 13*, p. 25, Pl. III, figs. 1, 2, Pl. VII, figs. 4, 5.

Remarks:—This group belongs to neither dimorphic Halysitinae nor monomorphic Cateniporinae, but takes an intermediate position.

It comprises 7 species as follows:

1) *Schedohalysites orthopteroides* (ETHERIDGE), (1904, from New South Wales)
2) *S. kanaurensis* (REED)*, (1912, from the Himalaya Mountains)
3) *S. hupehensis* (GRABAU), (1925, from Central China)
4) *S. pseudoorthopteroides* (TCHERNYCHEV), (1937, from Novaya Zemlya and Severnaya Zemlya)
5) *S. kuliki* (TCHERNYCHEV), (1938, from Yaigach Isl.)
6) *S. kitakamiensis* (SUGIYAMA), (1940, from Kitakami mountainland, Japan)
7) *S. yarrangobillyensis* n. sp.**, (HILL, 1954, from New South Wales)

The form 2 from the Lower Gotlandian formation has corallites of '*Catenularius*-type' in rounded oval shape in cross section and represents a distinct species, instead of a variety of *Halysites catenularius*. All others are Middle or Upper Gotlandian. See the writer's table (1956, pp. 136, 137) for their minute characters.

Distribution:—All in Asia and Australia; Gotlandian.

* Reported as *Halysites catanularia* var. *kanaurensis*.

** *Halysites* cfr. *lithostrotionoides* ETHERIDGE by HILL, 1954, pp. 38, 39, pl. IV, fig. 6.

Subfamily Halysitinae EDWARDS & HAIME, 1850, em.*

Diagnosis:—Halysitidae with mesocorallites.
Distribution:—Gotlandian.

Genus *Halysites* FISCHER VON WALDHEIM, 1813

FISCHER VON WALDHEIM, 1813, Zoognosia tabulis Synopticus, Edito III, p. 387.

Diagnosis:—This genus is easily distinguishable from others of Halysitinae by its complete tabulae of the mesocorallites and absence of septal spinules.

Genotype (by monotype):—*Tubipora catenularia* LINNAEUS, 1767, *Systema Naturae, Edito XII Reformata*, p. 1270.

Neotype (chosen by THOMAS and SMITH, 1954):—*Halysites catenularius* (LINNAEUS). Specimen No. 1 in BROMELL collection in Palaeontologiska Institution, Uppsala, Sweden, described and figured by BROMELL, 1728, p. 411, no. 5, fig. II on plate opposite page 410.

Remarks:—The species cited below are the undoubted *Halysites*.

1)	*Halysites agglomerata* HALL	M. Got.
2)	*H. amplitubulata* (LAMBE)	M. Got.
3)	*H. approximata* (EICHWALD)	Got.?
4)	*H. catenularius* (LINNAEUS)	Got.?
5)	*H. cratus* ETHERIDGE	Got.
6)	*H. infundibuliformis* BUEHLER	M. Got.
7)	*H. lata* (TCHERNYCHEV)	Got.
8)	*H. lithostrotionoides* ETHERIDGE	Got.
9)	*H. magnitubus* BUEHLER	M. Got.
10)	*H. meandrina* (TROOST)	M. Got.
11)	*H. nexus* DAVIS	M. Got.
12)	*H. regularis* FISCHER-BENZON	Got.
13)	*H. sussmilchi* ETHERIDGE	Got.

Distribution:—All from the Gotlandian formations, and mostly from the Middle Gotlandian.

Genus *Cystihalysites* TCHERNYCHEV, 1941

TCHERNYCHEV, B. B., 1941, *Vsesoyuznyy arkticheskiy institut Trudy, tom. 158*, p. 70, Leningrad.

* The name 'Halysitinae' had been once used by EDWARDS & HAIME (1850) as a tribe belonged to the Family Favositidae.

Diagnosis:—Halysitinae with strongly developed mesocorallites which have dissepiment-like incomplete tabulae.

Remarks:—Unfortunately the writer can not refer to the original description, and so he is much indebted to DUNCAN's work (1956). The high specialization of mesocorallite tabulae is clearly demonstrated in BUEHLER's plate (1955, fig. 4, Pl. 9). Tabulae in autocorallites are also sometimes incomplete. DUNCAN (1956) illustrated some examples based upon materials from Utah and California and figures published by AMSDEN and TCHERNYCHEV.

Baltic *Halysites cavernosa* FISCHER-BENZON (1871, from 'Silurian') is a close ally to *Cystihalysites brownsportensis* in mesocorallite tabulae. His plate (Taf. I, Figs. 2, 3, 5 and 6) examplifies strongly arched and incomplete tabulae, especially in the longitudinal sections of mesocorallites. He has already referred it to his group I A (with cellular interwall) emphasizing the feature to be unique. This fact indicates its being a *Cystihalysites*, but it differs from *C. brownsportensis* in its less constricted chains with larger autocorallites.

Though there is no precise description, *Halysites cavernosa* var. *reticulata* FISCHER-BENZON (1871, from Geschiebe von Goldingen an der Windau) seems also a member of the genus and probably a juvenile form of *C. cavernosa* judging from his definition of the variety.

Several chain corals with large mesocorallites, *Halysites catenularia* var. *amplitubulata* LAMBE (1899, from the Lower Helderburg at L'Anse a la Barbe and L'Anse au Gascon, Quebec, according to the original description; actually of Silurian age), for example, is closely related to this. Though LAMBE's figure (in SHROCK and TWENHOFEL, 1953) shows incomplete tabulae in mesocorallites and seems to be conspecific with *Cystihalysites brownsportensis*, the specimen from the Anticosti described by BUEHLER (1955, cited as *Halysites amplitubata**) has complete, straight tabulae in the mesocorallites.

Halysites labyrinthica GOLDFUSS (1836), LAMBE's (1900) second type of *H. catenularia* LINNAEUS (1767), *H. agglomerata* HALL (1843), *H. infundibuliformis* BUEHLER (1955), etc. have sometimes well developed mesocorallites with tabulae strongly convex upwards, but dissepiment-like incomplete tabulae are scarcely observable in them.

Chain corals which have been collectively called as *Halysites catenularia* in Europe should include some forms of this genus. None

* *Halysites amplitubata* seems to be a misprint of *H. amplitubulata*.

the like is, however, as yet known from Asia and Australia.

Distribution:—*C. brownsportensis* is found in the upper 50 feet of the Brownsport formation, 95 to 116 feet thick, and the superjacent Decatur limestone (10 to 70 feet) is considered to be the transition between the Devonian and Gotlandian. The subjacent strata about 100 feet in total thickness are classified into the Dixon and Lego, Waldron, Laurel, Osgood and Brassfield formations in descendant order. The last is underlain by Ordovician strata. Therefore the upper Brownsport formation seems to be correlated to the Upper Niagaran. *C.* aff. *brownsportensis* is reported from Utah and California by DUNCAN. The exact horizon of *N. cavernosa* is unknown.

Genus *Acanthohalysites*, nov.

Diagnosis:—Halysitinae with septal spinules in autocorallites.

Genotype:—*Halysites australis* ETHERIDGE, 1898, *Records of the Australian Museum, III, Pt. 4*, p. 78, Pl. XVII.

Remarks:—It is certain that the following species belong to this genus:—

1)	*Acanthohalysites labyrinthicus* (GOLDFUSS), 1826	M. Got.
2)	*A. australis* (ETHERIDGE), 1898	U. Got.
3)	*A. nitida* (LAMBE), 1899	M. Got.
4)	*A. radiatus* (WHITFIELD), 1903	M. Got.
5)	*A. gamboolicus* (ETHERIDGE), 1904	Got.
6)	*A. peristephesicus* (ETHERIDGE), 1904	Got.
7)	*A. pycnoblastoides* (ETHERIDGE), 1904	Got.
8)	*A. borealis* (TCHERNYCHEV)*, 1937	Got.
9)	*A. encrustans* (BUEHLER), 1955	M. Got.

Distribution:—The genus ranges from Lower? to Upper Gotlandian. The species 2, 5, 6, 7 and 9 are all from the Gotlandian of Australia, but it is a question whether the genus was most flourished in that region or whether most workers have overlooked the septal spinules, because they are not much developed in many forms.

Genus *Densoporites*, nov.

Diagnosis:—*Favosites*-like massive corallum with trigonal or tetragonal interspaces smaller than autocorallites; mesocorallites

* Originally described as *Halysites catenularia* var. *borealis*.

are present.

Genotype:—*Halysites compactus* ROMINGER, 1876, *Report Geol. Surv. Mich., Lower Peninsula, Vol. III, pt. 2*, pp. 78, 79, Pl. XXIX, fig. 3.

Lectotype (chosen by BUEHLER, 1955):—University of Michigan Museum, No. 8543. One of ROMINGER's syntypes, illustrated in the lower part of figure 3, plate 29 of ROMINGER's "*Fossil Corals*" (1876).

Remarks:—Corallum with closely packed corallites resembles *Halysites agglomerata* which often makes a similar compact massive corallum, but this species is distinguishable from the present form by the narrow, long and meandering lacunae. *H. agglomerata* var. *compactus* WHITEAVES (1895) is excluded from the genus by the same reason.

Halysites brevicatenatus HILL (1954) appears to belong to this genus, though its small figures do not show the details. It differs from *Densoporites compactus* in its smaller corallites, and has mesocorallites provided with slightly sagging tabulae.

Halysites compactus var. by NORTHROP (1937) also differs from the lectotype of the genus in its larger fenestrules without mesocorallites and long oval corallites as noted by him, and somewhat resembles *Densoporites brevicatenatus* (HILL) in the outline.

STEARN (1956) described '*Halysites compactus* ROMINGER' from Fischer Branch dolomite, southern Manitoba, Canada, but it differs from the lectotype in the absence of mesocorallites in the corallum.

TOLL's '*Halysites keyserlingi*' (1889) belongs probably to this genus as suggested by his statement that "The calyxapertures are nearly circular, have a diameter of 1–1.7 mm., and form centers in which 10 or more calices lie close together, whereby they maintain the appearance of the Favositidae". Unfortunately, however, nothing is mentioned of mesocorallites.

'*Halysites dissimilis*' EICHWALD (1829) perhaps belongs to the genus, but its brief description (in BUEHLER, 1955) does not allow one to make a precise comparison. The writer has no access to its original figure. Giving a brief description, EICHWALD (1860) casts the question as to its being a member of the Halysitidae, because of the massive corallum with very small fenestrules.

Distribution:—From Niagaran Group near Lake Michigan; Gotlandian in New South Wales, Australia.

On the Classification of the Halysitidae, II

By

Takashi HAMADA

Introduction

As a continuation of the proposal of a new classification in the preceding, its bearing on the evolution of the Halysitidae will be discussed in this paper. As the result of a comparative study on the specio-temporal transformation among some 90 forms in 9 genera* in 3 subfamilies six trends of evolution were emerged which are of prime importance to elucidate the phylogeny and distribution of the family in great detail. The reader will find that certain chain corals are keen time indicators when genera are defined in such precision as in the proposed classification.

I. Evolutional trends in the Halysitidae

Comparative studies on various halysitid corals show that there are several biocharacters which have changed from Ordovician to Gotlandian. More conspicuous changes are as follows:

(1) Without mesocorallites → with mesocorallites.
(2) Small corallites → large corallites.
(3) Rectangular autocorallites → rounded autocorallites in cross section.
(4) Horizontal tabulae → strongly convex tabulae → dissepiment-like incomplete tabulae in mesocorallites.
(5) Without septal spinules → with septal spinules → with rudimentary septal spinules.
(6) Small lacunae → large irregular, narrow or meandering lacunae of coralla.

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* Recently, HILL, D. and STUMM, E. C. (1956) placed a genus *Arcturia* WILSON (1931) in the Halysitidae. But the writer considers that the genus rather should belong to the Syringoporidae than the Halysitidae judging from its corallite junctions. It seems to be closely related to *Hayasakaia* LANG, SMITH and THOMAS (1940). DUNCAN, H. (1956, p. 224) noted that *Arcturia* and *Labyrinthites* are the syringoporoid corals which are probably synonymous.

1. Without mesocorallites → with mesocorallites.

"*Catenipora*" was originally instituted as a genus by LAMARCK (SMITH and THOMAS, 1954) for the Halysitidae without mesocorallites. "*Palaeohalysites*" by TCHERNYCHEV (1941) corresponds to a new subfamily Cateniporinae. The subfamily comprise four Ordovician genera, i. e. *Labyrinthites*, *Eocatenipora*, *Quepora* and *Catenipora* whereas the latter two survived in the Gotlandian period.

Ordovician chain corals are listed below.

Mid. Ord.	*Quepora quebecensis* (LAMBE)
,,	"*Halysites catenularia*" (LINNAEUS)*
,,	"*H. approximatus?*" EICHWALD*
Mid.? Ord.	*Quepora aequabilis* (TEICHERT)
Up. Ord.	*Labyrinthites chidlensis* LAMBE
Up. Ord.?	*Eocatenipora cylindricus* (WILSON)
Up. Ord.	*E. nicholsoni* (KIAER)
,,	*Quepora delicatulus* (WILSON)
,,	*Q. parallelus* (SCHMIDT)
,,	*Q. pulchellus* (WILSON)
,,	*Q. ? agglomeratiformis* (WHITFIELD)**
,,	*Catenipora borealis* (WILSON)***
,,	*C. escharoides* LAMARCK****
,,	*C. jacovickii* (FISCHER VON WALDHEIM)
,,	*C. microporus* (WHITFIELD)
,,	*C. robustus* (WILSON)
,,	*C. rubra* SINCLAIR and BOLTON
,,	*C. ? feildeni* (TROEDSSON), non ETHERIDGE
,,	*C. ? harti* (ETHERIDGE)
,,	*C. ? parvitubus* (LINDSTRÖM)
,,	*C. ? undulatus* (KIAER)

Neither dimorphic Halysitinae nor Schedohalysitinae (partly with, partly without mesocorallites) have as yet been reported from Ordovician rocks. The archaism and simplicity of the Cateniporinae show that the subfamily are ancestral to the other two subfamilies.

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* "*Halysites*" reported from the Ordovician formations in western and north-western Europe in old literatures must be checked out in the light of modern paleontology, before the generic reference is accepted.

** According to ROY (1941), it is a Richmondian rather than a Niagaran species.

*** Original designation is *Halysites gracilis* var. *borealis*.

**** This species from Ordovician formations is in doubt. See page 418.

2. Small to large corallites.*

Increase of corallite size is an important trend of evolution for chain corals, unless it depends upon the optimum condition of the habitat. They are generally very small in Ordovician forms, the largest being found in *Catenipora rubra* from the Upper Ordovician formation whose corallite measures about 1.5×2.0 mm. in cross section. The length 1.8–2.6 mm. measured on *Eocatenipora nicholsoni* is questionable.

Corallite size varies among Gotlandian species to such a great extent as shown in the Table 1 on page 410. The mean size** of corallite section is about 1.25×1.6 mm. for Middle Gotlandian forms, but in a few unusually large species which presumably lived in the optimum environment, corallites grew as large as 3.5×4.0 or 2.5×4.5 mm. in section. There are some smaller Gotlandian species which may indicate phyletic senility, if not unfavourable condition. The physical condition of environment is of course an important factor which controls corallite size. The fact that Gotlandian halysitid corals from Australia have all small corallites may be explained by the condition of seas where they lived.

How far the Halysitidae of different ages vary in autocorallite size is exemplified by the following species:

Mid. Ord.	*Quepora quebecensis*	1.0×1.5 mm.
Mid.? Ord.	*Q. aequabilis*	0.4–0.7×1.1–1.3 mm.
Up. Ord.	*Q. parallelus*	0.9×1.2 mm.
,,	*Q. delicatulus*	1.1×1.65 mm.
,,	*Catenipora rubra*	1.5×2.0 mm.
Mid. Got.	*Acanthohalysites radiatus*	1.0×1.5 mm.
,,	*A. encrustans*	1.0–1.25×1.0–1.5 mm.
,,	*Halysites agglomerata*	1.75×2.0 mm.

* The term, "corallite", in a broad sense means both autocorallite and mesocorallite, if the latter is present.

** In the consideration of evolution, logically, one cannot lay too much weight on a mean size of the halysitid corals from various localities in a given period. He will not be able to reach the final decision, unless any change of mean size is figured out through measurement of an extensive collection obtained from a large continuous section at a locality, although such an investigation has not as yet been done. Therefore the writer gathered data from literatures to grasp any concept of this subject.

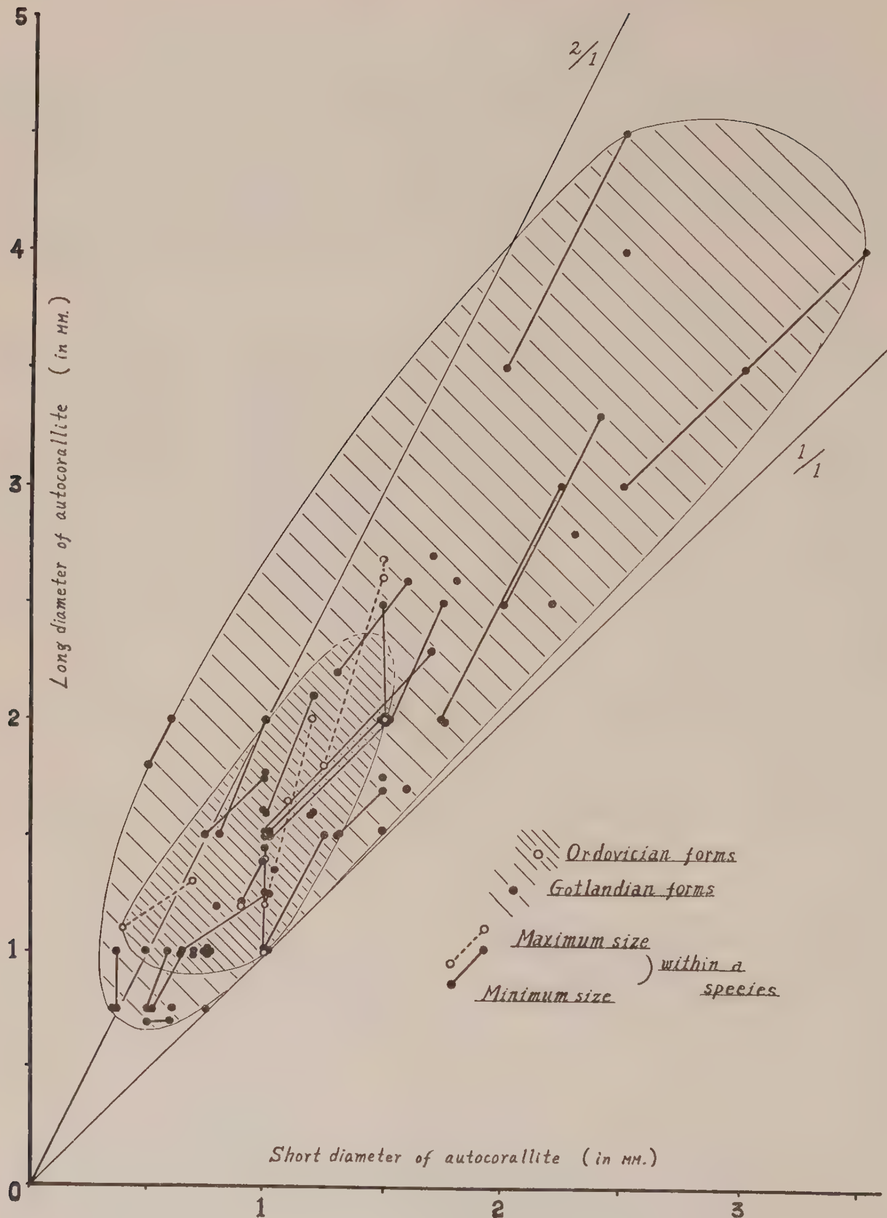

Table 1. Variation diagram of autocorallite size.

,,	*H. magnitubus*	2.5–3.0×3.0–3.5 mm. (max. 3.5×4.0 mm.)
,,	*H. nexus*	2.0–2.5×3.5–4.5 mm.
Up. Mid. Got.	*Cystihalysites brownsportensis*	1.5×2.0 mm.
Got.	*Catenipora minimus*	0.5–0.6×0.7 mm.
,,	*Schedohalysites pseudoorthopteroides*	1.0–1.9×1.5–2.3 mm.
,,	*Cystihalysites cavernosa*	2.0×2.5 mm. (max. 2.4×3.3 mm.)
,,	*Halysites lata*	2.3×2.8 mm.

The difference of corallite size between the Gotlandian and Ordovician species as shown in the variation diagram in Table 1, definitely proves that increase of corallite size is an important evolutional trend.

A similar tendency is recognized for mesocorallites, because the Halysitinae with large autocorallites have large mesocorallites in general.

3. Rectangular to rounded cross section of autocorallite.*

This trend of evolution is best shown in the Halysitinae. The Halysitinae which have relatively great, rounded or roundly ovate autocorallite sections, e. g. *Halysites agglomerata*, *H. amplitubulata*, *H. infundibuliformis* and *Acanthohalysites pycnoblastoides*, etc. flourished during the Middle Gotlandian period. No Ordovician species has rounded corallites with a reentrant part between two corallites in cross section except for *Eocatenipora*. *Densoporites compactus*, *Eocatenipora cylindricus*, and *E. nicholsoni* which have well rounded corallites are all highly specialized. Namely, the first is characterized by its compact mass of the corallites without interspaces larger than autocorallites, and the latter two have unusually isolated corallites in part of a corallum.

Most of others have elliptical or oval autocorallites. The Cateniporinae and the Schedohalysitinae include many species with less rounded or rectangular corallites. DUNCAN (1956) noted that primitive forms have more rectangular corallites than advanced ones.

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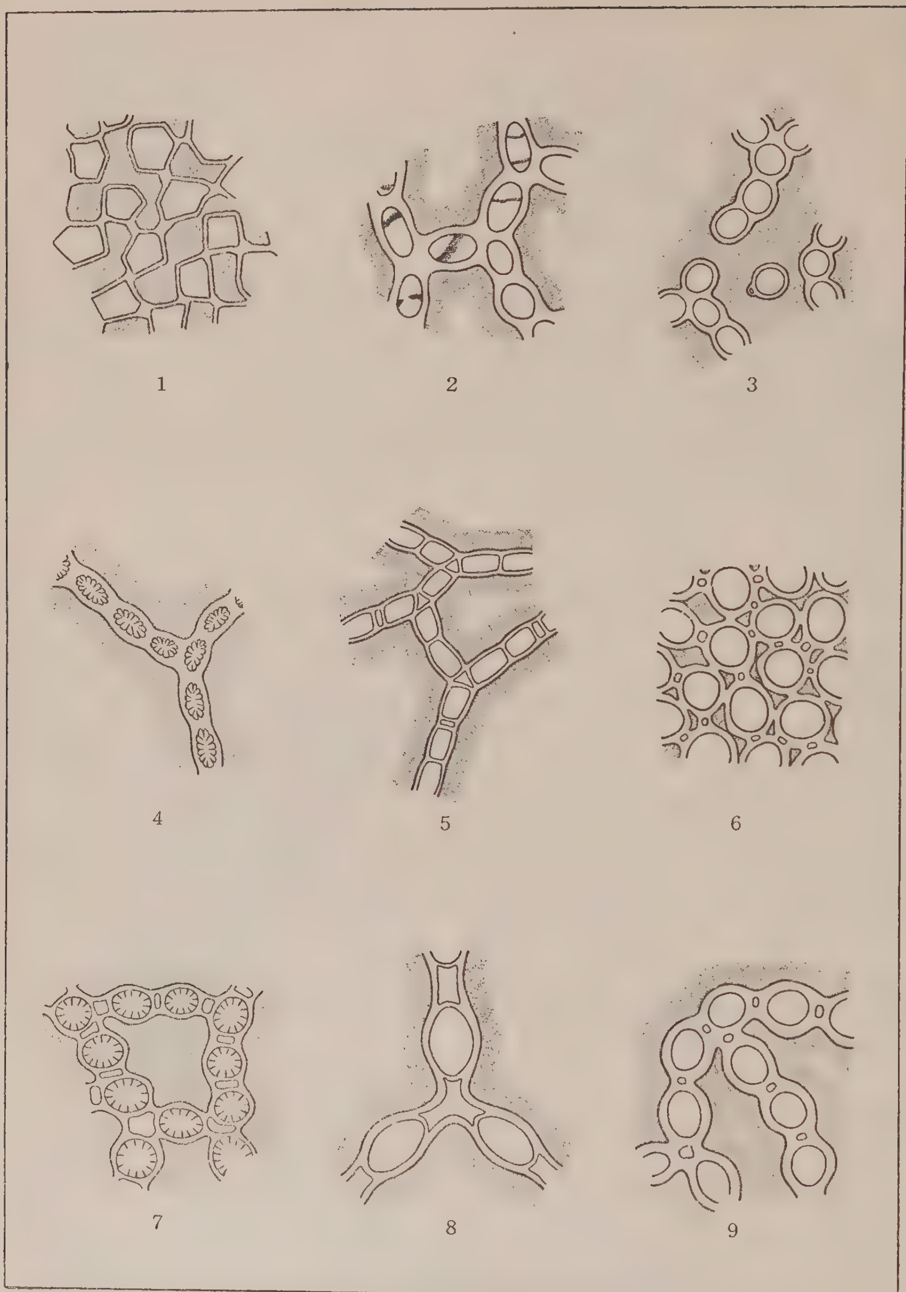
* No precise information concerning autocorallite shape can be obtained from the table 1, because each point on the table indicates a ratio of a short diameter to a long one of a corallite, instead of the roundness of the corallite.



Text-fig. 1. Variation of corallite shape of the Halysitidae.

The selected corallite shapes are diagrammatically shown in Text-fig. 1.

4. Horizontal to strongly convex, then to dissepiment-like incomplete tabulae in mesocorallites.

Generally speaking, tabulae in autocorallites of the Halysitidae show no conspicuous evolutional change, because in most species they are more or less variable in their curvature even in a corallum. The Cateniporinae, however, have mostly straight complete tabulae in the corallites. Incomplete autocorallite tabulae in a few specimens of *Catenipora gotlandicus* (YABE), *Halysites labyrinthicus* GOLDFUSS, and *Acanthohalysites pycnoblastoides* (ETHERIDGE), all in YABE's plates (1915), reveal pathologic injuries in parts of the coralla.

Tabulae in mesocorallites on the contrary, change in accordance with other changes. Although many small Middle Gotlandian species have complete horizontal tabulae in mesocorallites, tabulae tend to be curved in comparatively large forms of the same age, especially in the species having well developed mesocorallites, and at last tabulae become incomplete and dissepiment-like in the genus *Cystihalysites* (Text-fig. 2). Some remarkable instances are cited below:

A) With straight or slightly curved tabulae in mesocorallites.

Halysites amplitubulata BUEHLER, non LAMBE	Mid. Got.
H. catenularius (LINNAEUS)	Got.?
Acanthohalysites peristephesicus (ETHERIDGE)	Got.

Explanation of Text-figure 1

Typical cross sections of the Halysitidae.

1) *Labyrinthites chidlensis* LAMBE, ×20 (after LAMBE, 1906)
2) *Quepora quebecensis* (LAMBE), ×4.4 (after BUEHLER, 1955)
3) *Eocatenipora cylindricus* (WILSON), ×5 (after WILSON, 1926)
4) *Catenipora microporus* (WHITFIELD), ×5.4 (after BUEHLER, 1955)
5) *Schedohalysites kitakamiensis* (SUGIYAMA), ×4.4
6) *Densoporites compactus* (ROMINGER), ×3.8 (after BUEHLER, 1955)
7) *Acanthohalysites encrustans* (BUEHLER), ×4.4 (after BUEHLER, 1955)
8) *Cystihalysites brownsportensis* (AMSDEN), ×4.4 (after BUEHLER, 1955)
9) *Halysites labyrinthicus* GOLDFUSS, ×4.4 (after YABE, 1915)

All figures are diagrammatically shown.

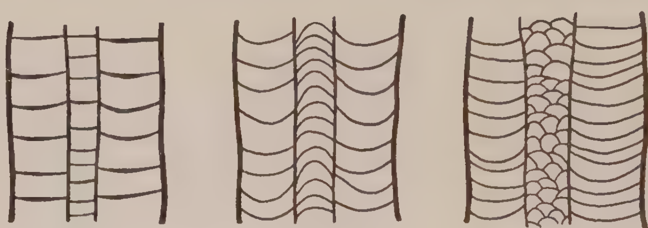
B) With strong convex tabulae in mesocorallites.

Halysites agglomerata Hall	Mid. Got.
H. infundibuliformis Buehler	"
Acanthohalysites encrustans (Buehler)	"

C) With dissepiment-like incomplete tabulae in mesocorallites.

Cystihalysites brownsportensis (Amsden)	Up. Mid. Got.
C. cavernosa (Fischer-Benzon)	Got.

In the B group mesocorallites are usually provided with strongly convex tabulae, although there are a few specimens described as "concave" or "convex upward" tabulae, *Halysites magnitubus* Buehler (1955) for example.



Text-fig. 2. Evolution of mesocorallite tabulation.
a) *Halysites amplitubulata* Buehler, non Lambe, ×5.6
b) *Halysites agglomerata* Hall, ×4.2
c) *Cystihalysites brownsportensis* (Amsden), ×4.2
All figures are diagrammatically shown after Buehler's plates (1955).

5. Without septal spinules → with septal spinules with rudimentary septal spinules.

Whether the presence or absence of septal spinules in mesocorallites can bear generic distinction of halysitid corals is a matter of discussion. The writer's opinion was already expressed in the preceding paper (1957).

The oldest chain coral is non-septate *Quepora* from which was derived *Catenipora* or the Cateniporinae with septal spinules. There are two types in the genus, namely the one with and the other with-

out a pseudocolumella. Which of the two is primitive is, however, difficult to say, because their stratigraphical positions as listed already (1957, p. 400) are not so accurate as the question is solved. The Halysitinae and Schedohalysitinae which are more advanced than the Cateniporinae, are the Gotlandian subfamilies mostly flourished in the middle of the period when appears septate *Acanthohalysites* in which the pseudocolumella or even strong septal spinules are never seen, while the Cateniporinae range from Ordovician to Middle Gotlandian.

6. Small to large, and then to irregular or meandering lacunae of coralla.

Most of the Cateniporinae have relatively regular and small lacunae and *Catenipora microporus* (for example, TEICHERT, 1937 Pl. 8, fig. 4; BUEHLER, 1955, Pl. 6, fig. 5) is an instance of the subfamily having the most intricated lacunae, while *Quepora simplex* is a large form with long chains of corallites. *Catenipora rubra* is always characterized by great length and smooth curvature of chains and their rectangular corallites. The species is one of the largest in the Ordovician Cateniporinae.

The Gotlandian Halysitinae and Schedohalysitinae, however, have often irregular narrow, labyrinthine or meandering lacunae. Hence the names *Halysites labyrinthicus* and *H. meandrina*, etc.

It is a remarkable fact that most species with large corallites have large and complicated lacunae. Small angular lacunae composed of three, four or five corallites are often seen in Ordovician and Gotlandian small species such as *Quepora quebecensis*, *Catenipora minimus*, *Catenipora hillae* n. sp., etc. This tendency is also proved even in a corallum ontogenetically in most chain corals which have radiate coralla.

The largest chain of autocorallites is reported of *Halysites agglomerata* by HALL (1852, Pl. 35, fig. 2b). In fact 41 autocorallites are countable in its illustration, although it is unknown to the writer whether the aspect is emphasized in the picture or not.


MAP 1
DISTRIBUTION
OF
ORDOVICIAN HALYSITIDAE

II. Distribution of the Halysitidae

1. The Ordovician period.

The Ordovician halysitids are well known from North America, especially from the Arctic region of the continent, and also from Great Britain and Baltic region. There are some twenty species in the period as already listed on page 408, while no Ordovician form is reported from Australia and Asia except for a few Siberian species.

The Ordovician chain corals are *Labyrinthites*, *Quepora*, *Eocatenipora* and *Catenipora* of the subfamily Cateniporinae. Most of them are described from North America and only seven species from northern Europe and Russia. While American chain corals are fairly well studied by several modern paleontologists, most of Europian ones have been collectively called "*Halysites catenularia*" which compre-

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Localities of Ordovician Halysitidae shown in Map 1.

Middle Ordovician

a: Ste Anne de Chicoutimi, Lake St. John, Quebec, Canada; a′: Lake Timiskaming, Quebec, Canada; b: Bache Peninsula, Ellesmere Land; c: Pembrokeshire, Wales, G. B.; d: Dagö Isl. (=Os. Khiuma), Esthonia; e: Esthonia.

Upper Ordovician

1: Washington Land, Northwest Greenland; 2: King William Land, East Greenland; 3: Grinnel Land, East Coast of Ellesmere Land; 4: Sutton Island, etc., Dolphin and Union Strait, Canada; 5: Iglulik Island; 6: Melville Peninsula; 7: Lake Nettiling, Southern Baffin Land; 8: Brobisher Bay, Southern Baffin Land; 9: Southampton Island; 10: Cape Chidley, Hudson Strait; 11: Hudson Bay Region, Manitoba, Canada; 12: Southern Manitoba, Canada; 13: Southeast British Columbia, Canada; 14: Lake Timiskaming, Ontario, Canada; 15: Anticosti Island; 16: Perce, Quebec; 17: Northern Michigan; 18: Winnebago Area, Wisconsin; 19: Western South Dakota & Northeast Wyoming; 20: Bayhorse & Gilmore, South-Central Idaho; 21: Marathon, Texas; 22: Central Texas; 23: Westmoreland & Cross Fell Inlier, England; 24: Pembrokeshire & Carmathenshire, Wales, G. B.; 25: Mt. Sulitelma, etc., Norway; 26: Kalstad, Meldalen, Norway; 27: Island of Stord, Bergen Area, Norway; 28: Oslo & Ringerike, Norway; 29: Dalarne, Sweden; 30: Västerbotten Co., Sweden; 31: Öland, Sweden; 32: Esthonia Region; 33: Aktschat Tau, Southwestern Russia; 34: Steinige Tunguska, Siberia; 35: Cosna-Nowitna Region, Alaska; 36: White Mts., northeast of Fairbanks, Alaska; 37: Yukon-Alaska International Boundary; 38: Mackenzie Mts., Yukon, Canada; 39: Seward Peninsula, Alaska.

hends various kinds and hence it is a large species.

Some halysitids from Great Britain, Esthonia and North America are as old as Middle Ordovician.

The oldest species is *Halysites catenularia* (LINNAEUS) described by MURCHISON (after M. EDWARDS and HEIME, 1850) from the Llandeilo flags of Robestom Walthen and Sholeshook, Pembrokeshire, Wales. "*Halysites catenularia*" in these days, however, was not far removed from the term "chain corals".

Halysites approximatus? EICHWALD from the upper Jewe formation (D_1) of Esthonia (after BASSLER, 1950) is the second which again seems to be obscure in its generic diagnosis for the same reason as above mentioned.

Middle Ordovician chain corals are also known from the middle Black River of the Upper Mississippi Valley (after FOERSTE, 1924) and the Norman Lockyer Island, east coast of Grinnel Land (after HOLTEDAHL, 1913). But, they are all obscure in their diagnosis.

The last is *Halysites catenularia* var. *quebecensis* by LAMBE (1899) from the Black River formation between the mouth of the Metabechuan River and Blue Point, Lake St. John, Quebec which is recently restudied by BUEHLER (1955) and SINCLAIR (1955). It is the Cateniporinae without septal spinules, or genus *Quepora* by SINCLAIR.

The so-called "*Halysites catenularia*" and some other seventeen species from the Upper Ordovician are widely distributed in North America and Northwest Europe. The most significant is *Catenipora rubra* SINCLAIR and BOLTON, or the so-called *Catenipora gracilis*, well known chain coral in North America. "*Halysites*" *parallelus* SCHMIDT in the Baltic region and Siberia is similar to *Catenipora rubra*. This is, however, a *Quepora*, judging from FISCHER-BENZON's description, and reported also from the Gotlandian rocks of the areas.

Catenipora escharoides, genotype of *Catenipora*, which was obtained as a boulder on the seashore of Esthonia has been thought an Upper Ordovician species, but there is no definite proof except for the aspect of the rock specimen. Most other "*Halysites* (or *Catenipora*) *escharoides*" from various localities bear some doubt on their generic references, because the name has been often used for general expression of chain corals as well as "*Halysites catenularia*".

The Ordovician localities are plotted in the map on page 416. The oldest so far known, is Pembrokeshire, Wales. Then chain

corals were widely spread into boreal seas in the Upper Ordovician period.

2. The Gotlandian period.

This is the age of the Halysitidae. The five oldest of the period are "*Halysites catenularia*" and "*H. escharoides*" from the Lower Valentian of the Girvan district, Ayrshire, Scotland, "*H. catenularia*" from the E_1 of Bohemia, "*H. catenularia*" and *Catenipora microporus* from the Becscie formation (lower Albion) of the Anticosti Island, Canada.

There are many younger ones in Europe and North America. The Middle Gotlandian was the acmic prominence for the Halysitidae. All genera of the family, i. e. *Halysites, Acanthohalysites, Cystihalysites* and *Densoporites* have appeared in the period, while two genera of the Cateniporinae i. e. *Quepora* and *Catenipora* survived until the end of the Middle Gotlandian period. The two others of the subfamily, *Labyrinthites* and *Eocatenipora,* have been extinguished in the Upper Ordovician.

The oldest in Asia is *Schedohalysites kanaurensis* which was obtained from the horizon 6 (Lowest Gotlandian) in Spiti, Himalaya. This is at the same time the oldest of the Schedohalysitinae which are the subfamily widely distributed in Asia, Australia and Siberia in the Middle and Upper Gotlandian period. Moreover these regions, especially Australia, are characterized by the occurrences of chain corals with small and slender corallites as already mentioned.

The Halysitidae were declined and their distribution is restricted in the Upper Gotlandian. The Keyser Group is the highest horizon yielding chain corals in North America*. In the Oslo region it is the 9d zone with *Spirifer elevetus* probably Middle Ludlovian in age. In Great Britain, the latest "*Halysites catenularia*" is reported from the Aymestry limestone of Aymestry, Herefordshire, England.

WEISSERMEL, W. (1939) figured out some Gedinnian chain corals from Kartal and Pendik, Southeast of Üsküdar, Asia Minor. They are *Halysites catenularius* var. *longicatenata*, *H.* cf. *catenularius*, *H.* cf.

* CLARKE, J. M. (1909) reported *Halysites catenularia* from the Lowest Devonian (*N. Y. State Mus., Mem. 9*). Unfortunately, the writer cannot refer to the paper.


MAP 2
DISTRIBUTION OF GOTLANDIAN HALYSITIDAE

gotlandicus, and *H. escharoides*. The first is closely allied to *Halysites agglomerata* in the corallum characters. But there are feebly developed septal spinules in some autocorallites. Hence the form should

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Localities of Gotlandian Halysitidae shown in Map 2.

1: Seward Peninsula, Alaska; 2: Cape Jefferson, Offley Island, North Greenland; 3: Southeastern King William Land, Eastern Greenland; 4: Cape Hilgard & Cape Frazer, etc., Eastern Ellesmere Land; 5: Southwestern Ellesmere Land; 6: Prince Regent's Inlet; 7: Southampton Island; 8: Franklin Mountains, Mackenzie, Canada; 9: Donald, British Columbia, Canada; 10: Saskatchewan River & Lake Winnepegosis, Manitoba, Canada; 11: Winisk River, Manitoba, Canada; 12: Shammattawa River, Manitoba, Canada; 13: Ekwan River, Ontario, Canada; 14: Notre Dame Bay, etc., Northern Newfoundland; 15: Anticosti Island; 16: Gascons, etc., Gaspe Peninsula; 17: Rimouski, Gaspe Peninsula; 18: Lake Timiskaming, Southwest Quebec, Canada; 19: Piscataquis Co., North-Central Maine; 20: Penobscot Bay Area, Maine; 21: Littleton, New Hampshire; 22: Several localities near New York; 23: Lockport & Sweden, etc., Western New York; 24: Durham & Guelph, etc., Ontario, Canada; 25: Manitoulin & Drummond Island, etc.; 26: Manistique River & Mackinac, Michigan; 27: Milwaukee & Green Bay Area, Wisconsin; 28: Preston, Idaho; 29: Gold Hill & Fish Spring, Utah; 30: Inyo Co., California; 31: Masonville, Iowa; 32: Hamburg, Western Illinois; 33: Wabash River & Hutington, etc., Northern Indiana; 34: Hillsboro, Ohio; 35: Louisville, etc., Kentucky; 36; Perry Co., etc., Tennessee River Valley, Tennessee; 37: Collinsville, etc., Northeastern Alabama; 38: Mayo & Kerry Cos., etc., Ireland, G.B.; 39: Girvan District, Ayrshire, Scotland, G.B.; 40: Isle of Man, G.B.; 41: Dudley & Wenlock, etc., England & Scotland, etc., G.B.; 42: Gröningen, Holland; 43: Schleswig Holstein & Eifel, etc., Germany; 44: Lodenitz, Bohemia; 45: Sadewitz, Silesia; 46: Oslo Region, Norway; 47: Gotland Island; 48: Dagö Isl., & Hapsal, etc., Esthonia; 49: Windau, etc., Courland, Western Esthonia; 50: Kowno & Königsberg (=Kaliningrad), Lithuania; 51: Vilna, Lithuania; 52: Kamenetz Podolski, Podolia (Ukraine); 53: Prinzen Insel, etc., Anthirovitha, Turkey; 54: Mashigin Bay, Novaya Zemlya; 55: Yaigach Island; 56: Cape Konstantinovski & Usa, etc., Gulf of Petchora; 57: Ice Sea Shore of Timan Range; 58: Severnaya Zemlya; 59: Taymir Peninsula, Siberia; 60: Olenek River, Northern Siberia; 61: Khatanga River, Northern Siberia; 62: Unter Tunguska, Siberia; 63: Steinige Tunguska, Siberia; 64: Kotelny Island; 65: Upper part of Kolyma River Basin, Eastern Siberia; 66: Tarbagatai Range, Central Asia; 67: Central Ferghana Range, Central Asia; 68: Kanaur, Spiti, Himalaya; 69: Tshautien, Northeast Szechuan, China; 70: Noluping, Ichang-fu, Hupeh, China; 71: Tapeishan, Northeastern Hupeh, China; 72: Ken-niho, Northwest Korea; 73: Kitakami Mountainland, Northeastern Honshû, Japan; 74: Kii Peninsula, Honshû, Japan; 75: Several localities in Shikoku, Japan; 76: Central Kyûshû, Japan; 77: Central Range of New Guinea; 78: Chillagoe, North Queensland, Australia; 79: Wellington & Yass, etc., New South Wales, Australia; 80: Northeast Gippsland, Victoria, Australia; 81: Liena, Mersey River, Tasmania.

be a *Acanthohalysites*. Concerning the second, the specimen is so poorly preserved that one cannot designate the genus. "*Halysites*" *gotlandicus* and "*H.*" *escharoides* are *Catenipora* as already mentioned.

This generic assemblage of the chain corals is common in the Middle Gotlandian of North America and Europe. Besides, the faunal list of the Gedinnian corals on his page 121, et seq. strongly suggests that they are closely related to the Gotlandian fauna in the Baltic Region.

Many Asiatic or Australian halysitids bear some obscurity in their chronology, but some are probably Upper Gotlandian. The latest among them is "*Halysites*" *sindoensis* from the Siluro-Devonian passage bed in the upper part of the Kolyma River Basin, Siberia (RUKHIN, 1938; after BASSLER, 1950). Besides, HOLTEDAHL (1924) placed a *Halysites* zone for the same horizon in the northern Novaya Zemlya, although the specific name was not given.

The distribution of the Gotlandian Halysitidae is figured in the map 2. The writer is greatly interested in the distribution of the Halysitidae when he found such restricted patches of the localities as seen in the maps of the Ordovician and Gotlandian species. The chain corals are not reported from South America, Antarctica and Africa (?)*. Whether or not the fact means that the areas are actually barren of the chain corals is an interesting question.

III. Phylogeny of the Halysitidae

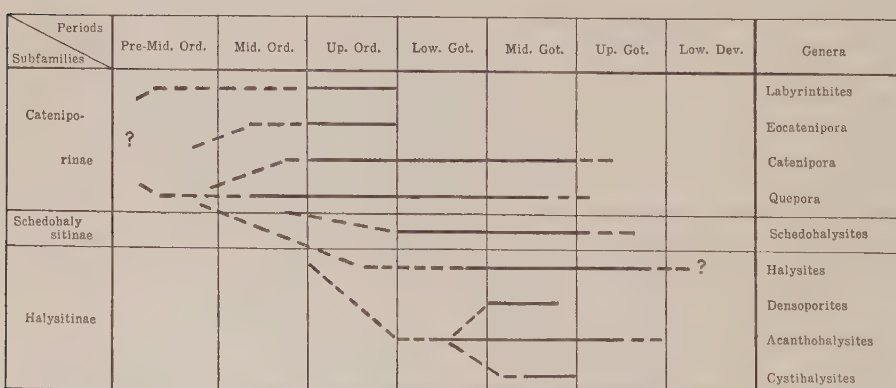

Table 2. Phylogeny of the Halysitidae.

* HILL & STUMM (1956, p. 469) cited Africa as one of the localities of *Halysites*.

As above described, the oldest genus is simple *Quepora* which mainly flourished during the Upper Ordovician. *Catenipora* is also a primitive genus probably derived from *Quepora* and lived in the Upper Ordovician and Gotlandian. *Labyrinthites* and *Eocatenipora* were extinguished by the end of the Ordovician period.

While the Halysitinae and Schedohalysitinae appeared in the Early Gotlandian, and *Cystihalysites* and *Densoporites* are two genera of the former subfamily lived during the Middle Gotlandian. The Halysitidae were most prevalent in the Middle Gotlandian when there are seven genera of the family except for *Labyrinthites* and *Eocatenipora*. It is noteworthy that the most advanced chain corals like *Cystihalysites* and the other Halysitinae with large, rounded autocorallites occur in the Middle Gotlandian formations. *Densoporites* is an extremely speciallized Middle Gotlandian chain coral derived from *Acanthohalysites*.

Synoptic list of species

aequabilis Teichert, 1937, *Halysites* .... *Quepora*
agglomerata Hall, 1843, *Halysites* .... *Halysites*
agglomeratiformis Whitfield, 1900, *Halysites* .... *Quepora ?*
amplitubulata Lambe, 1899, *Halysites catenularia* var. .... *Halysites*
approximata Eichwald, 1829, *Catenipora* .... *Halysites ?*
attenuata Fischer von Waldheim, 1828, *Halysites* .... *Halysites ?*
australis Etheridge, 1898, *Halysites* .... *Acanthohalysites*
australis Hill, 1954, *Halysites* cf. .... *=hillae*
borealis Wilson, 1931, *Halysites gracilis* var. .... *Catenipora*
borealis Tchernychev, 1937, *Halysites catenularius* var. .... *Acanthohalysites*
brevicatenatus Hill, 1954, *Halysites* .... *Densoporites*
brownsportensis Amsden, 1949, *Halysites catenularia* var. .... *Cystihalysites*
catenularius Linnaeus, 1767, *Tubipora* .... *Halysites*
cavernosa Fischer-Benzon, 1871, *Halysites* .... *Cystihalysites*
chillagoensis Etheridge, 1904, *Halysites* .... *Catenipora*
communicans Eichwald, 1829, *Catenipora* .... *Catenipora*
compactus Rominger, 1876, *Halysites* .... *Densoporites*
compactus Whiteaves, 1895, *Halysites agglomeratus* var. .... *=agglomerata*
compactus var. Northrop, 1939, *Halysites* .... *Catenipora*
compressa Milne-Edwards & Haime, 1849, *Catenipora* .... *Catenipora ?*
cratus Etheridge, 1904, *Halysites* .... *Halysites*
cylindricus Wilson, 1926, *Halysites* .... *Eocatenipora*
delicatulus Wilson, 1926, *Halysites* .... *Quepora*
dichotoma Fischer von Waldheim, 1828, *Halysites* .... *Halysites ?*

dissimilis EICHWALD, 1829, *Catenipora* .... *Densoporites ?*
distans EICHWALD, 1829, *Catenipora* .... *=catenularius ?*
elegans FISCHER-BENZON, 1871, *Halysites* .... *Catenipora*
encrustans BUEHLER, 1955, *Halysites* .... *Acanthohalysites*
escharoides LAMARCK, 1816, *Catenipora* .... *Catenipora*
escharoides OZAKI, 1934, *Halysites* .... *Quepora*
exilis EICHWALD, 1829, *Catenipora* .... *Catenipora ?*
feildeni, ETHERIDGE, 1878, *Halysites catenulatus* var. .... *Quepora ?*
gamboolicus ETHERIDGE, 1904, *Halysites* .... *Acanthohalysites*
gotlandicus YABE, 1915, *Halysites* .... *Catenipora*
gracilis LAMBE, 1900, *Halysites catenularia* var. .... several forms*
gracilis LEITH, 1944, *Halysites*, par. .... *Manipora***
gracilis LEITH, 1944, *Halysites*, par. .... *=rubra*
harti ETHERIDGE, 1878, *Halysites catenulatus* var. .... *Catenipora ?*
hillae HAMADA, 1957, *Catenipora* .... *Catenipora*
hupehensis GRABAU, 1925, *Halysites* .... *Schedohalysites*
huronensis TEICHERT, 1937, *Halysites* .... *Quepora*
infundibuliformis BUEHLER, 1955, *Halysites* .... *Halysites*
irregularis TEICHERT, 1937, *Halysites* .... *Eocatenipora ?*
jacovickii FISCHER VON WALDHEIM, 1828, *Halysites* .... *Catenipora*
japonicus SUGIYAMA, 1940, *Halysites* .... *Catenipora ?*
kanaurensis REED, 1912, *Halysites catenularia* var. .... *Schedohalysites*
keyserlingi TOLL, 1889, *Halysites* .... *Densoporites ?*
kitakamiensis SUGIYAMA, 1940, *Halysites* .... *Schedohalysites*
kuliki TCHERNYCHEV, 1938, *Halysites* .... *Schedohalysites*
labyrinthica GOLDFUSS, 1826, *Catenipora* .... *Halysites*
lacustris SINCLAIR, 1955, *Quepora ?* .... *Quepora ?*
lata TCHERNYCHEV, 1937, *Halysites catenularius* var. .... *Halysites*
lithostrotionoides ETHERIDGE, 1904, *Halysites* .... *Halysites*
lithostrotionoides HILL, 1954, *Halysites* cf. .... *=yarrangobillyensis*
longicatenata WEISSERMEL, 1939, *Halysites catenularius* var. .... *Acanthohalysites ?*
macrostoma FISCHER VON WALDHEIM, 1828, *Halysites* .... *Halysites ?*
magnitubus BUEHLER, 1955, *Halysites* .... *Halysites*
major MILNE-EDWARDS & HAIME
maxima FISCHER-BENZON, 1871, *Halysites obliqua* var. .... *Quepora*
meandrina TROOST, 1840, *Catenipora* .... *Halysites*
michelini CASTELNAU, 1843, *Catenipora* .... *Acanthohalysites ?*
microporus WHITFIELD, 1882, *Halysites catenulatus* var. .... *Catenipora*
microporus SHROCK & TWENHOFEL, 1939, *Halysites catenularia* .... *Halysites*
microstoma FISCHER VON WALDHEIM, 1828
minimus TCHERNYCHEV, 1929, *Halysites* .... *Catenipora*
nexus DAVIS, 1885, *Halysites* .... *Halysites*
nexus FOERSTE, 1890, *Halysites catenulatus* var. .... *Halysites ?*
nicholsoni KIAER, 1929, *Halysites* .... *Eocatenipora*

* SINCLAIR & BOLTON, 1956.
** SINCLAIR, 1955.

nitida LAMBE, 1899, *Halysites catenularia* var.	*Acanthohalysites*
obliqua FISCHER-BENZON, 1871, *Halysites*	*Catenipora*
orthopteroides ETHERIDGE, 1904, *Halysites*	*Schedohalysites*
parallelus SCHMIDT, 1861, *Halysites*	*Quepora*
parallelus YABE, 1915, *Halysites*	*Catenipora*
parrii KÖNIG, 1824, *Catenipora*	*Catenipora ?*
parvitubus LINDSTRÖM, 1880, *Halysites*	*Catenipora ?*
peristephesicus ETHERIDGE, 1904, *Halysites*	*Acanthohalysites*
pseudoorthopteroides TCHERNYCHEV, 1937, *Halysites*	*Schedohalysites*
pulchellus WILSON, 1926, *Halysites*	*Quepora*
pycnoblastoides ETHERIDGE, 1904, *Halysites*	*Acanthohalysites*
quadrata FISCHER-BENZON, 1871, *Halysites*	*Catenipora*
quebecensis LAMBE, 1900, *Halysites catenularia* var.	*Quepora*
radiatus WHITFIELD, 1903, *Halysites*	*Acanthohalysites*
rasmusseni TEICHERT, 1939, *Halysites*	*Quepora*
regularis FISCHER-BENZON, 1871, *Halysites*	*Halysites*
reticulata EICHWALD, 1829, *Catenipora*	*Catenipora*
reticulata FISCHER-BENZON, 1871, *Halysites cavernosa* var.	*Cystihalysites*
robustus WILSON, 1926, *Halysites*	*Catenipora*
rubra SINCLAIR & BOLTON, 1956, *Catenipora*	*Catenipora*
sapporiensis OZAKI, 1934, *Halysites*	*Quepora ?*
sexto-catenatus OWEN, 1862, *Halysites*	*Halysites ?*
simplex LAMBE, 1899, *Halysites catenularia* var.	*Quepora ?*
sindoensis OZAKI, 1934, *Halysites*	*Quepora*
stenostomata FISCHER VON WALDHEIM, 1818, *Halysites*	*Halysites ?*
sussmilchi ETHERIDGE, 1904, *Halysites*	*Halysites*
taimyrica TCHERNYCHEV, 1937, *Halysites parallelus* var.	*Halysites ?*
undulata KIAER, 1897, *Halysites escharoides* var.	*Catenipora ?*
wallichi REED, 1912, *Halysites*	*Catenipora ?*
yarrangobillyensis HAMADA, 1957, *Schedohalysites*	*Schedohalysites*

Postscript:—*Halysites elongatus* was newly described by YÜ (1956) from the Middle Gotlandian rocks in the Chiuchüan Basin, Western Kansu, Northwestern China. This new species clearly belongs to the genus *Halysites* sensu stricto. YÜ referred to a Korean species *H. sapporiporoides* in his remarks, but the name should be a misprint for *H. sapporiensis*.

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Studies on the Ostracoda from Japan

I. Subfamily Leptocytherinae n. subfam.

By

Tetsuro HANAI

Abstract

This paper is part of a basic taxonomic study of Ostracoda found living in the sea surrounding Japan and as fossils in Neogene and Quaternary deposits in Japan. As a result of this study, it was found that Leptocytherinae have gradationally variable dentition, but can be classified into three genera, *Leptocythere* G. O. SARS, *Callistocythere* RUGGIERI, and *Tanella* KINGMA, on the basis of the hinge structure.

Table of Contents

Introduction

The Leptocytherinae are among the most common ostracods found in the sea surrounding Japan and its vicinity. From this area, two Leptocytherine ostracods have been described, *Cythere*

crispata BRADY (1868) and *Cythere rectangulata* KAJIYAMA (1912). The species described by BRADY was based upon specimens collected from Hongkong Harbor by the Challenger Expedition. The species described by KAJIYAMA came from the beach near Misaki, Miura Peninsula, Japan.

This report deals with the subfamily Leptocytherinae n. subfam., mainly found in and adjacent to Japan. This subfamily is characterized by a hinge structure transitional from merodont to modified entomodont with containant[1] and by polyfurcate radial pore canals. In this paper, the type species of *Leptocythere*, 12 species of *Callistocythere*, one species of *Tanella* are described or illustrated; all but three of these are new.

Acknowledgements

Preliminary studies on these Ostracoda were commenced at the University of Tokyo, Japan, under the guidance of Prof. Teiichi KOBAYASHI, and were continued under Prof. Takao SAKAMOTO, to both of whom I am deeply indebted for guidance and continued encouragement.

This paper was prepared in the United States under the direction of Prof. H. V. HOWE, Director of the School of Geology, Louisiana State University. I am deeply indebted to Dr. Howe for his helpful suggestions and criticisms and for access to his type collections and his library.

Mr. R. L. ARTUSY of Houston, Texas, and Dr. P. C. SYLVESTER-BRADLEY of the University of Sheffield, England, have contributed helpful suggestions. Part of the samples were provided by Mr. T. UCHIO, and by Mr. T. OGOSE of the University of Tokyo, Japan. Miss Laura LAURENCICH has helped the writer with translations. Finally the manuscript was edited by Mr. A. H. CHEETHAM of Louisiana State University. To all of these people, I should like to express my deep gratitude.

1) The term containant is here used for a groove of the left valve, which contains or accomodates the dorsal edge of the opposite valve as typified by the subfamily Leptocytherinae. The containant opens anteriorly and posteriorly into the valve interior, or into anterior and posterior sockets which open interiorly.

Types

All holotypes are deposited in the type collection of the Geological Institute, University of Tokyo, Japan, and paratypes are deposited in the H. V. HOWE Collection, School of Geology, Louisiana State University, Baton Rouge, Louisiana, U. S. A.

Historical Review

For many years the Leptocytherine ostracods were included in the genus *Cythere* O. F. MULLER; in fact, some workers such as G. W. MÜLLER considered them to be typical *Cythere*. In 1925, G. O. SARS proposed the generic name *Leptocythere*,[1] designating *Cythere pellucida* as genotype.

He pointed out that this *Leptocythere* differed from the genus *Cythere* s. l. "by very narrow and elongate shape of the shell, the wholly confluent eyes and also by some other particularities in the structural details". He also included under *Leptocythere* all nine species which G. W. MÜLLER (1894) had described from the Gulf of Naples under the name *Cythere*. Thus G. W. MÜLLER's generic description is essentially a description of leptocytherine ostracods. In his description, MÜLLER divided "*Cythere*" into two groups:

1) Shell of female less than twice as long as high. (=*Callistocythere*)
2) Shell of female more than twice as long as high. (≒*Leptocythere*)

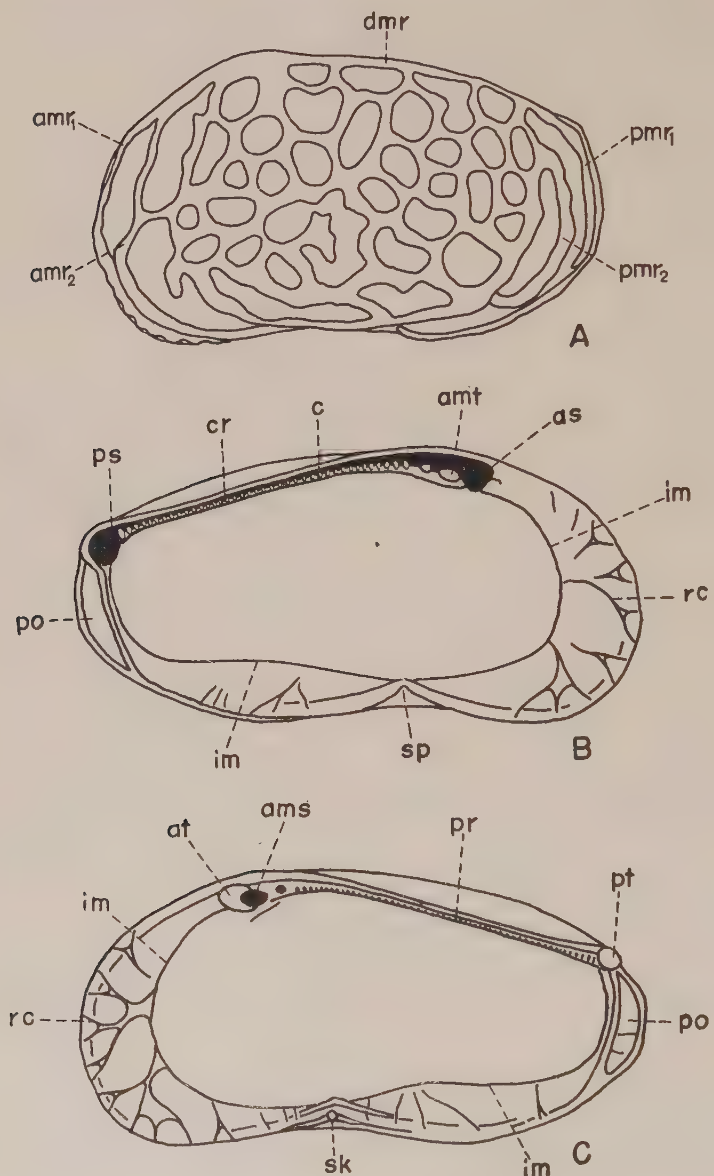
ROME (1942) followed G. W. MÜLLER, rather than SARS, and in so doing divided the genus *Cythere* into the following three groups:

1) Section of *Cythere lutea* O. F. MÜLLER
2) Section of *Cythere lobiancoi* G. W. MÜLLER
3) Section of *Cythere fabaeformis* G. W. MÜLLER

Of the above sections, 1) belongs to *Cythere* s. str., 2) and 3) belongs to Leptocytherinae. As already pointed out by SARS (1925) and

1) In the original description, SARS (1925) used the name *Leptocythera* at the head of his description. However, in the description of his species and in the explanation of his plates, he used *Leptocythere*. It is obvious that *Leptocythera* is a typographical error. Therefore in accordance with Article 19 of the International Rules of Zoological Nomenclature, I will here use the name *Leptocythere*.

BLAKE (1931) the confusion between *Cythere* and *Leptocythere* was due to the fact that the older work was based not so much on the type species of *Cythere* as on other species which later workers have



assigned to various genera. BLAKE (1931) and SYLVESTER-BRADLEY (1941) gave detailed descriptions of the carapace of *Cythere lutea*, the type species of *Cythere*. There can be no doubt that *Leptocythere* has a notably different carapace, not only in shape, but in the character of the radial pore canals and hinge structure. These differences are too great for their retention in the same subfamily. I am, therefore, erecting a separate subfamily for *Leptocythere* and other genera which have characters closely similar.

In 1953, RUGGIERI divided the genus *Leptocythere*, into two subgenera, *Leptocythere* s. str. and *Callistocythere* RUGGIERI. The first group of *Cythere* species described by G. W. MÜLLER (1894) and ROME'S (1941) *Cythere lobiancoi* section correspond to RUGGIERI'S subgenus *Callistocythere*. Since 1925, when SARS proposed the generic name *Leptocythere*, many species have been described or reported under the name of *Leptocythere* by KLIE (1929a, 1929b, 1933, 1938, 1939a, 1939b, 1942) BLAKE (1933), DUBOWSKY (1939), ELOFSON (1941),

Text-figure 1. A. *Callistocythere nipponica* HANAI, n. sp., lateral view of left valve showing reticulation and marginal ridges; B, C. *Callistocythere japonica* HANAI, n. sp., internal views of left (B) and right (C) valves, showing structure of the carapace.

Key to terms

amr_1: first anterior marginal ridge.
amr_2: second anterior marginal ridge.
dmr: dorso-posterior marginal ridge.
pmr_1: first posterior marginal ridge.
pmr_2: second posterior marginal ridge.
as: anetrior socket.
amt: anterior teeth of median element.
c: containant.
cr: crenulate ridge.
ps: posterior socket.
po: posterior apparent opening.
im: inner margin.
sp: snap-pit.
rc: polyfurcate radial pore canals.
at: anterior tooth.
ams: anterior sockets of median element.
pr: pited ridge.
pt: posterior tooth.
sk: snap-knob.

Triebel (1941, 1947), Pokorny (1943, 1944, 1945, 1952), Mehes (1941), Van den Bold (1946), Hessland (1946), Kingma (1949), Tressler and Smith (1948), Ruggieri (1950, 1952, 1953), Swain and Peterson (1951, 1952), Hornibrook (1952a, 1952b, 1953), Kay (1954), Hartmann (1954), and Swain (1955). There are, however, still many leptocytherine species described before 1925 under the name *Cythere*, whose generic position has not been changed by later authors.

Systematic Description

Family CYTHERIDAE Baird, 1850

Subfamily LEPTOCYTHERINAE Hanai, n. subfam.

Type Genus:—Leptocythere C. O. Sars, 1925.

Diagnosis:—Carapace elongate to subquadrangular in lateral outline, usually with a distinct posterior cardinal angle. Suaface nearly smooth to deeply sculptured, some species with anterior and posteroventral marginal ridges. Marginal area broad with trifurcate or polyfurcate radial pore canals. Hinge usually modified entomodont. A groove below flange and above median bar of left valve receives or accomodates the median element of the right valve and opens into the anterior and posterior sockets. Anterior tooth and socket structure, and the twofold median element vary in different genera.

Description:—Carapace comparatively small, elongate to subquadrangular in lateral outline, with distinct posterocardinal angle. Surface punctate, reticulate, or with undulating ridges. Calcareous portion of inner lamella comparatively broad; radial pore canals moderately spaced, trifurcate or polyfurcate. Adductor muscle scars hard to distinguish, a row of four scars normally present. Eye confluent. Hinge of right valve consists of anterior and posterior teeth with an intermediate shelf. Teeth usually faintly crenulated. Shelf socketed or pitted, usually having one or two prominent pits at anterior end. Hinge of left valve consists of anterior and posterior sockets and an intermediate ridge. Anterior socket sometimes obscure. Anterior and posterior sockets connected with a containant just above intermediate ridge. Ridge crenulated and having one or two prominent teeth at anterior end. Often the pits or sockets

of the anterior end of the median element of right valve disappear, and the teeth of left valve become anti-slip teeth.[1]

Remarks:—The relatively small size of the carapace and the distinct angulation of the posterocardinal angle also serve to distinguish this subfamily. G. W. MÜLLER has shown that the radial pore canals as well as some of the normal pore canals are connected with the touch-hairs and enclose the nerves for perception. Therefore, polyfurcate radial pore canals (polyfurcate distribution pattern of nerves) is a relatively important taxonomic characteristic. According to TRIEBEL (1954), complication of the radial pore canals of the marginal zone is a characteristic which appears at a phylogenetically late stage.

This subfamily includes the following genera:

Leptocythere SARS, 1925

Callistocythere RUGGIERE, 1953

Tanella KINGMA, 1948

The following genera are similar in some details to the Leptocytherinae. However, in each case, I feel that they possess certain details of carapace structure which tend to exclude them from the subfamily Leptocytherinae.

Hemikrithe VAN DEN BOLD, 1950: The bifurcated radial pore canals, hinge structure, and posterocardinal angulation are similar to genera in the Leptocytherinae. However, the shape of the vestibule, mode of bifurcation of the radial pore canals, and structure of the hingement do not exactly fit with those of the leptocytherine Ostracoda.

Ilyocythere KLIE, 1939: According to KLIE (1939), this genus is anatomically close to *Leptocythere*. The shape of the carapace and the shell structure, however, are quite different.

Age:—Age relationships in the subfamily Leptocytherinae are at present difficult to determine with certainty. TRIEBEL (1941) questionably assigned two specimens of ostracods from the Dogger of Germany to *Leptocythere*. SWAIN and PETERSON (1951, 1952) described *Leptocythere imlayi* from the Upper Jurassic Sundance forma-

1) The term anti-slip tooth was used by KINGMA (1948) and VAN DEN BOLD (1950) for the tooth of *Tanella, Javanella* or *Hemikrithe* which prevents the anterior tooth of the opposite valve from slipping out of its socket. This type of tooth has no complementary socket in the opposite valve.

tion of Wyoming and Swift formation of Montana. Leptocytherine ostracods have not yet been reported from Cretaceous deposits. From the Tertiary, HORNIBROOK (1952, 1953) reported Eocene and Oligocene *Leptocythere* s. l. from New Zealand. Most of the described species of *Leptocythere* s. l. are from European Neogene deposits, but some are from North American and southeast and east Asian deposits of the same age. Many of these Neogene species belong to *Callistocythere* rather than to *Leptocythere* s. str. The genus *Tanella* has so far been reported only from Pliocene and later deposits in Sumatra.

Genus LEPTOCYTHERE SARS, 1925

Cythere auct. (part.)
1894 *Cythere* G. W. MÜLLER (part.), pp. 350–352.
1925 *Leptocythere* SARS (part.), pp. 171, 172.
1942 *Cythere* ROME (part.), pp. 18, 19.
Leptocythere auct. (part.)[1)]
1953 *Leptocythere* (*Leptocythere*) RUGGIERI, pp. 95, 96.

Type Species:—Cythere pellucida BAIRD, 1850.

Diagnosis:—Carapace elongate; surface nearly smooth to punctate. Vestibule moderate. Median hinge element of left valve has one tooth at the anterior end; corresponding socket of right valve is obscure.

Description:—Carapace thin, oblong and elongate in outline; posterior cardinal angle distinct; ventral margin sinuous. Surface finely punctate. Calcareous portion of inner lamella broad at anterior and posteroventral ends. Vestibule well developed. Radial pore canals comparatively few and typically bifurcate or trifurcate. Hingement of right valve consists of slightly crenulate anterior and posterior teeth, and a long smooth or faintly crenulate intermediate bar. Posterior tooth stronger than anterior. Hingement of left valve consists of anterior and posterior sockets connected by a containant which received median bar of right valve. A long crenulate ridge lies just below the containant between the terminal

1) Generic descriptions of the internal organs of *Leptocythere* s. l. are given by KLIE (1929, 1938), TRESSLER and SMISH (1948), and of the carapace are given by VAN DEN BOLD (1946), KINGMA (1948) and SWAIN and PETERSON (1951).

sockets. Anti-slip-teeth present at anterior end of intermediate bar. An anti-slip-tooth-like projection is present in front of the anterior socket and just below the posterior socket.

Sexual dimorphism: Dimorphism is strong. The main differences between male and female carapace are 1) male forms are more elongate and narrower than female forms; 2) female forms have more rounded outline and are more tumid in the posterior area.

Remarks:—The second group of G. W. MÜLLER's (1894) classification of the genus *Cythere*, which is characterized by the carapace of the female being about twice as long as high, and the *Cythere fabaeformis* section of ROME's (1942) classification, correspond to *Leptocythere* in a strict sense.

Leptocythere pellucida (BAIRD), 1850

Text-fig. 2, G. H.

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1863 —— —— G. O. SARS, Beretning om en i Sommeren 1862 foretagen zoologisk Reise i Christianias og Trondhjems Stifter. *Nyt Magazin for Naturvidenskaberne*, vol. 12, pp. 250, 251.

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1931 *Leptocythere pellucida* Müller, Die Ostracoden des arktischen Gebietes. *Fauna Arctica* VI, 1, p. 28.

1938 —— —— Stephensen, Marine Ostracoda and Cladocera. *Zool. of Iceland* III, 32. Copenhagen and Reykjavik, p. 6.

Remarks:—Specimens for comparison in this paper came from Dog's Bay, County Galway, Ireland.

Genus CALLISTOCYTHERE Ruggieri, 1953

Cythere auct. (part.).

1894 *Cythere* G. W. Müller (part.), pp. 350–352.

1925 *Leptocythere* Sars (part.), pp. 171, 172.

1942 *Cythere* Rome (part.), pp. 18, 19.

Leptocythere auct. (part.)

1953 *Leptocythere* (*Callistocythere*) Ruggieri, p. 99.

Type Species:—*Cythere littoralis* G. W. MÜLLER, 1894.

Diagnosis:—Carapace elongate to subquadrangular; surface sculptured by reticulation and undulating ridges. Vestibule poorly developed. More than two anterior terminal teeth of median hinge element of left valve usually enlarged; corresponding sockets of right valve distinct. Color usually yellow.

Description: Carapace thick, comparatively small, compressed laterally. In side view, subquadrangular, posterior cardinal angle distinct, dorsal margin nearly straight, ventral margin sinuous; anterior margin more broadly rounded than posterior. Surface reticulate or with undulating ridges; anterior and posterior marginal ridges well developed. Calcareous portion of inner lamella is broad

in anterior and posteroventral regions. Line of concrescence almost coincides with inner margin. Radial pore canals polyfurcate and lobate, becoming serrate near the margin in weathered specimens. Hingement of the right valve consists of an anterior tooth, intermediate finely pitted shelf which has one or often more than one prominent socket or pit at its anterior termination, and a subquadrate posterior tooth; anterior and posterior teeth slightly crenulate. Hingement of left valve consists of anterior socket, intermediate crenulated ridge which has one or often more than one tooth of nearly equal size at its anterior termination, and a posterior socket; posterior socket opens interiorly. Anterior and posterior sockets of left valve are connected through a containant which runs between flange and intermediate crenulate ridge. Tooth-like projections of an anti-slip nature are present in front of the anterior socket and below the posterior socket. The marginal contact areas of the two valves are fairly broad around the anterior and in the posteroventral region. The ventral sinuous margin of the right valve has a groove with a knob which is located on the outer wall of the groove, and is here called a "snap-knob". The left valve has a selvage-like strong ridge with a "snap-pit" on the outer side of the ridge, which corresponds to the groove and "snap-knob" of the right valve.

Sexual dimorphism: The female form is larger and more quadrangular than the male form in side view. In dorsal view, the female form appears broader than the male, especially in the posterocentral area. Sometimes the surface sculpture of the male form is somewhat stronger than that of the female form, especially in the posteroventral area. *Cythere pavonia* BRADY has cup-shaped excavations or loculi on the posteroventral surface of the shell. This type of excavation is found in female forms of some Paleozoic ostracods. TRIEBEL (1914) questionably assigned this species to the genus *Leptocythere* s. l., and is of the opinion that these excavations do not serve as a brood pouch. The same type of cup-shaped excavations are found in *Callistocythere* sp. which is described by BRADY as *Cythere crispata* in the Challenger Report.

Comparison: The genera, *Leptocythere* and *Callistocythere* possess a very similar shell structure. However, in *Leptocythere*, the shell is comparatively thin, whereas in *Callistocythere*, strong deposition

of shell material modifies and accelerates the surface ornamentation and the hinge structure. The following differences are recognizable:

Carapace; In general, *Leptocythere* has a more elongate and a thinner carapace than *Callistocythere*. The surface of *Leptocythere* is rather smooth or finely punctate, and the ornamentation is usually weak, whereas in *Callistocythere*, the surface of the carapace is strongly ornamented by reticulation or undulation of irregularly arranged ridges. Viewed from above, *Leptocythere* has a rather smooth posterocentral surface, whereas *Callistocythere* has often an angulated posterocentral surface owing to the strong development of posterior marginal ridges. The "snap-knob and -pit" structure on the ventral sinuous margin develops characteristically in *Callisto cythere;* however, it is not always present in *Leptocythere*.

Hinge structure; *Callistocythere* has a well developed hinge structure in which both valves tightly articulate with each other. On the contrary, hingement of *Leptocythere* is fragile and the teeth and sockets do not articulate very well. The right valve of *Callistocythere* has one or more prominent pits just behind the anterior tooth, a feature not present in *Leptocythere*. These pits correspond to the knobs just behind the anterior socket of the left valve. In *Leptocythere* the pits are lacking or obscure, because the teeth at the anterior termination of the intermediate ridge of the right valve fit under the median ridge of the left instead of into sockets, as in *Callistocythere*. The crenulation of the intermediate ridge is more distinct in *Callistocythere* than in *Leptocythere*. In *Leptocythere*, the line of concrescence runs irregularly near the middle of the marginal area and a definite vestibule is developed. However, in *Callistocythere* the line of concrescence runs close to the inner margin and often it coincides with the inner margin.

Ecology; Leptocytherine ostracods have been reported from shallow marine, brackish, and fresh water environments. (KLIE, 1939). The European *Leptocythere* s. str. shows a certain preference for brackish water environments. Around Japan, *Callistocythere* is found in littoral sands. *Leptocythere* is reported from cold water, whereas, *Callistocythere* is predominant in warm water. (RUGGIERI, 1953).

Remarks:—The first group of G. W. MÜLLER's classification (1894), which is represented by *Cythere* with the carapace of the female

less than twice as long as high, and the *Cythere lobiancoi* section of ROME's classification (1942), correspond to *Callistocythere*. POKORNY (1952) observed in leptocytherine ostracods, a gradual transition of hingement from a merodont type to an amphidont type, because of the enlargement of the anterior terminal teeth of the crenulate ridge of the left valve. *Callistocythere* has dentition related to entomodont, but differs in having more than one strong tooth, (usually two such teeth) at the anterior termination of the crenulate intermediate ridge of the left valve. In this character it is close to *Xenocythere* but differs from that genus in having a containant in the left valve, and in the development of anti-slip teeth. *Callistocythere* can be subdivided into two groups, *C. littoralis* group and *C. japonica* group according to differences in the shape of the carapace and in the details of hinge structure.

1. *Callistocythere littoralis* group

Carapace comparatively thick, subquadrangular in lateral outline. Ornamentation strong. The two or more anterior terminal teeth of the left valve and corresponding sockets of the right valve definitely enlarged. Vestibule poorly developed. Color yellow.

Callistocythere sp.

1880 *Cythere crispata* G. S. BRADY, Challenger Report, Zoology, vol. 1, pp. 72, 73, pl. XIV, figs. 8a–d.

Remarks:—Cythere crispata BRADY (1868) was originally described from Tenodos in the eastern Mediterranean. Its carapace has a surface which is "exceedingly irregular, marked with waved rounded and irregularly flexuous ridges." In BRADY's Challenger Report, (1880) another specimen was figured from the Pacific as *C. crispata*. It came from either Port Jackson, Booby Island, or Hongkong Harbor. Brady indicated that this Pacific form is characterized by a reticulate shell surface which was "sculptured all over with closely-set angular excavations of irregular form and size." It is also noteworthy that the form figured shows crescentic excavations on the ventral surface of the carapace. In 1890 BRADY described *C. crenata* from Noumea, New Caledonia, and from other south Pacific localities and placed the forms he had previously reported

from Port Jackson, Booby Island, and Hongkong in the synonymy of this new species. However, the type of *C. crenata* as figured by BRADY shows a more or less flexuous surface, "marked with undulated ridges very variable in their development enclosing between them fossae of irregular shape and size." From this it will be seen that the species figured in the Challenger Report was different from the Mediterranean *C. crispata* BRADY, and also different from the later *C. crenata* BRADY in both surface ornamentation and outline. None of the forms figured by BRADY have been encountered in my Japanese collections.

Callistocythere rectangulata (KAJIYAMA), 1913

1913 *Cythere rectangulata* KAJIYAMA, Dobutsugaku-zasshi (Zool. Mag.) vol. 25, no. 291, pp. 10, 11, pl. 1, figs. 56–60.

Remarks:—This species was described by KAJIYAMA from Misaki, Miura Peninsula, Kanagawa Prefecture, Japan. The original description is written in Japanese. The species is characterized by the prominent posteroventral ridge which continues to the anteroventral area, runs along the ventral margin, projects below the posteroventral margin, turns upward near the posterior end, makes three projections in the posterior area and ends in the posterodorsal area.

Callistocythere nipponica HANAI, n. sp.

Pl. VII, figs. 1a, b; Pl. X, fig. 4; text-figs. 1, A; 2, C, D.

Description: Carapace oblong to subquadrangular in side view; highest at anterior cardinal angle; anterior outline obliquely rounded with about 10 small projections at end of radial pore canals, especially in lower half of anterior margin; dorsal outline gently convex and sloping toward posterior; ventral outline slightly sinuous near middle; posterior outline truncated, rounded below. Most of surface sculptured by coarse and deep reticulations, which are rather uniformly developed except immediately below and behind the place of muscle-attachment where one or more cross ridges appear to be lacking. A row of small projections along anterior contact margin becomes a ridge ventrally which runs along the

ventral contact margin, slightly digresses from the margin in the ventral sinuous area, curves around the posterior margin and ends near the posterocardinal angle. A second anterior marginal rim starts at the anteroventral margin, and runs upward along the anterior margin, but digresses from the margin in the upper half and ends near the anterocardinal angle. A dorsoposterior marginal ridge starts behind the eye spot and is sufficiently high to obscure the straight hinge line; it curves around the upper two-thirds of the posterior end before dying out where the two dorsoposterior and ventroposterior ridges fuse side by side. A second posterior ridge starts downward from just in front of the posterior cardinal area and then curves to parallel the posterior marginal rim. It terminates in the posteroventral area where it connects with the reticulate pattern of the surface. In dorsal view the carapace falsely appears to be constricted immediately behind the area of muscle-attachment. This appearance is due to the failure of certain reticulate ridges to develop in this immediate area. Anterior and posterior marginal ridges give slight angulation to the dorsal view. The dorsal surface of each valve is flattened. These flat surfaces slope toward each other so as to make a V-shaped through along the hinge line. Each flattened area is crossed by about four transverse ridges which are slightly oblique to the hinge line. In end view, the carapace is subovate, broadest at a point a little below mid-height. Ventral surface slightly flattened. Eye spot small. The line of concrescense almost coincides with the inner margin, and the vestibule is extremely narrow. The duplicature is wide at anterior and posteroventral regions. Radial pore canals moderately numerous and polyfurcate outwardly. At the anteroventral margin, they extend to each marginal projection where the polyfurcations are most distinctive. Some branches of the radial pore canals terminate between the margin of the carapace and the marginal rim. The normal pore canals are few in number and relatively large in size, and are scattered over the surface between reticulations. The muscle-scar pattern is located slightly lower than center, below and behind the central pit, and consists of at least four slightly elongated, closely spaced scars. Each scar is raised as a tubercle on the inside of the valve. The selvage is prominent in both valves, especially strong in the ventral sinuous margin. In the left valve,

the selvage serves as a ridge which is a complement to the flange groove of the right valve. On the contrary, in the right valve the selvage serves as an inner wall of the flange groove. In the ventral sinuous part of the right valve, the flange has a "snap-knob". In the left a corresponding "snap-pit" cuts the flange, reaches to the selvage, and opens outwardly. The hinge of the right valve consists of an anterior faintly crenulate tooth, two sockets, a long and minutely pitted intermediate ridge, and a slightly crenulate posterior tooth. The intermediate ridge is almost straight, makes an angle of about 155° with anterior teeth and two sockets, and an angle of about 145° with the posterior tooth. The hinge of the left valve consists of an anterior socket, two teeth, an intermediate crenulate ridge and a posterior socket. The anterior and posterior sockets open to the interior. Between the intermediate ridge and the flange, there develops a containant which connects the anterior and posterior sockets.

Dimensions: Holotype (complete carapace) length 0.65 mm., height 0.36 mm., thickness 0.30 mm.; paratype (complete carapace) length 0.62 mm., height 0.35 mm., thickness 0.30 mm.

Occurrence: All types were collected from Recent beach sand from the shore back of an Imperial villa, Hayama-machi, Kanagawa Prefecture, where it is rare.

Remarks: This species shows some relation to *Callistocythere* sp. described by BRADY (1880) as *Cythere crispata* (BRADY 1880, pp. 72, 73, pl. XIV, figs. 8 a–d). However, the distinct anterior marginal rims, the posteroventral ridge, and the surface ornamentation at the ventral part of the valves in this species is quite different from those in the latter species. Furthermore, *Callistocythere nipponica* HANAI does not possess the small loculi-like excavations which are characteristic of BRADY's species.

Callistocythere reticulata HANAI, n. sp.

Pl. VIII, figs. 2a–d.

Description: Carapace oblong, subreniform, highest at the anterior cardinal angle. Anterior margin obliquely rounded, with about five small projections at termination of radial pore canals, especially along lower half of anterior margin. Dorsal margin

gently arched and inclined backward. Posterior cardinal angulation distinct. Posterior margin truncated above, rounded below. Ventral margin moderately sinuous near middle. Surface sculptured by dense and deep reticulations. Anterior marginal ridge weak; beginning at the middle of the anterior margin, it runs along the anteroventral margin to the ventral sinuation. The second anterior marginal ridge runs from the eye spot to the anterocentral area. A dorsoposterior marginal ridge starts behind the eye spot and is sufficiently high to obscure the hinge line. It reaches to the lower part of the posterior margin. The second posterior ridge runs from the posterodorsal area, is prominent in the posteroventral area, and ends in the ventral sinuous margin. In the dorsal view, the carapace is elongate ovate, widest in the posterocentral area, but slightly compressed in the central muscle-scar area. The troughs between the first and second anterior marginal ridges, and the first and second posterior marginal ridges are prominent in dorsal view. Dorsal surface of the valves forms a V-shaped trough along the hinge line. In end view the carapace is subovate. Sexual dimorphism fairly strong; male form slightly narrower in side view, and more compressed in dorsal view, especially at the posterocentral area.

Dimensions:—Holotype (male complete carapace) length 0.52 mm., height 0.27 mm., thickness 0.20 mm.; allotype (female complete carapace) length 0.53 mm., height 0.30 mm., thickness 0.25 mm.; paratypes (male complete carapace) length 0.53 mm., height 0.27 mm., thickness 0.21 mm.; (female complete carapace) length 0.56 mm., height 0.31 mm., thickness 0.25 mm.

Occurrence:—All type specimens were collected from Recent beach sand from the shore back of an Imperial villa Hayama-machi, Kanagawa Prefecture, where they are common.

Remarks: This species closely resembles *Callistocythere nipponica* HANAI; it is, however, smaller and differs in lateral outline. The reticulation is denser in this species and the pattern of the marginal ridges is quite different from *Callistocythere nipponica*, especially in the second posterior marginal ridge. Among the European species, *Leptocythere bacesoci* (ROME) from Recent and Quaternary deposits of Monaco and Italy is closely related to this species. This species has coarser reticulations than the European species.

Callistocythere alata HANAI, n. sp.

Pl. VII, figs. 4a, b; Pl. X, fig. 5.

Description:—Carapace oblong in side view, somewhat tumid, highest at anterocardinal angle. Anterior margin obliquely rounded, with about eight small projections at terminations of radial pore canals, especially along lower half of anterior margin. Dorsal margin slightly arched, sloping gently toward posterior. Posterior cardinal angle distinct in left valve, obscure in right valve. Posterior margin rounded below. Ventral margin very slightly sinuous near middle. Surface sculptured by coarse and deep reticulations. The second anterior marginal ridge begins at the anterior cardinal angle, digresses from the middle of the anterior margin, then follows the anterior margin closely to the ventral margin, where it connects with the prominent ventral marginal ridge. The second posterior marginal ridge branches from the first posterior marginal ridge near the posterior cardinal angle and curves downward almost to the ventral margin. A straight ventral ridge begins at the junction with the anterior margin. It runs backward away from the ventral contact margin and terminates in a spine, which gives an alate appearance in side view. In dorsal view the carapace is seen to be widest in the posterocentral area. The flat dorsal surface of both valves makes a V-shaped trough along the hinge-line. The trough is deepest at the posterior end. The posterior marginal rim and the second posterior marginal ridge form projections near the posterior end when viewed from above. Viewed from in front the carapace is seen to be subovate in the anterior half and subpentagonal in the posterior half because of the ventrolateral ridges. The marginal area, adductor muscle-scar patterns and hinge structure are similar to those of the other species of this genus. Sexual dimorphism is weak; the carapace of the female form is somewhat larger than that of the male form, and is widest at the posterocentral area, whereas the male form is widest at the central area.

Dimensions:—Holotype (male complete carapace) length 0.57 mm., height 0.30 mm., thickness 0.27 mm.; allotype (female complete carapace) length 0.59 mm., height 0.33 mm., thickness 0.29 mm.; paratype (female complete carapace) length 0.59 mm., height 0.33 mm., thickness 0.29 mm.

Occurreuce:—Holotype and allotype specimens were collected from Recent beach sand at the shore behind the Mitsui Biological Station, Hamazaki-mura, Kamo-gun, Shizuoka Prefecture. (coll. by HANAI, 14/1 1953) Paratype specimens were collected from Recent beach sand at the shore behind the Imperial Villa, Hayama-machi, Kanagawa Prefecture, where they are rare.

Remarks:—The straight ventral ridge with the spine at its posterior termination characterizes this species. It has some resemblance to *Callistocythere nipponica* HANAI. However, in its coarser reticulation and straight ventral ridge, it clearly differs from the latter species.

Callistocythere rugosa HANAI, n. sp.

Pl. VIII, figs. 3a–d.

Description:—Carapace small, oblong, subreniform, highest at the anterior cardinal angle; anterior margin obliquely rounded; terminations of the radial pore canals form about seven slight projections along the anterior margin. Dorsal margin straight, posterior dorsal slope somewhat concave. Ventral margin sinuous near middle. Surface sculptured by numerous flexures, two longitudinal trends being the most prominent. Reticulation on a small scale develops in the anterodorsal, anteroventral, posterodorsal, and posteroventral areas. The second posteroventral marginal ridge is prominent and runs from the posterior part of the dorsal margin to the ventral sinuous margin, making a strong posterior angulation in dorsal view. The second anterior marginal ridge is strong and runs from the upper part of the anterior margin to the anteroventral area. The marginal area and muscle-scar pattern are similar to those of *Callistocythere nipponica* HANAI. The hinge is likewise similar but is more strongly arched in *Callistocythere nipponica*. In the dorsal view, the carapace appears compressed and irregularly subhexagonal with both the anterior marginal ridge and the posteroventral marginal ridge projected. In the end view, the carapace is subhexagonal in outline.

Sexual dimorphism is very slight. The female form is thicker in ventral view and slightly larger than the male form, and is quadrangular in shape.

Dimensions:—Holotype (male complete carapace) length 0.46 mm., height 0.25 mm., thickness 0.17 mm.; allotype (female complete carapace) length 0.45 mm., height 0.25 mm., thickness 0.20 mm.; paratypes (male complete carapace) length 0.44 mm., height 0.24 mm., thickness 0.17 mm.; (female complete carapace) length 0.47 mm., height 0.27 mm., thickness 0.21 mm.

Occurrence:—All type specimens were collected from Recent beach sand from the shore back of an Imperial villa Hayama-machi, Kanagawa Prefecture. (coll. by T. HANAI, 30/11 1952)

Remarks:—This species is closely related to *Cythere crenata* BRADY (BRADY 1890, vol. 35, pt. II, no. 14, pp. 497, 498, pl. II, figs. 35, 36). However, BRADY's species has one row of undulating ridges disposed more or less longitudinally while my Japanese species has two longitudinal rows of ridges. BRADY's species also lacks the reticulations of *Callistocythere rugosa*.

Callistocythere undata HANAI, n. sp.

Pl. VIII, figs. 1a–d.

Description:—Carapace thick, small, subquadrangular in side view, highest at anterior cardinal angle; anterior margin broadly and obliquely rounded with about five small projections along the anteroventral margin. Ventral margin sinuous at middle. Posterior margin truncated above and rounded below. Dorsal margin slightly arched. The posterodorsal complex of strong surface ornamentation slightly projects over the dorsal margin in side view. Posterocardinal angle distinct.

Surface ornamented by strong, large and blunt ridges, which have a tendency to run more or less vertically in the dorsal area, and transversely in the ventral area. The anterior marginal ridge is strong. It begins near the eye spot and continues to the anteroventral margin. A strong ridge occurs at the anterocardinal angle, runs down through the eye tubercle, and joins with the anterior marginal ridge at the middle of the anterior margin. The posteroventral marginal ridge is especially strong at the posteroventral margin. The second posterior ridge is strongest in the posteroventral area. The posterior hinge tubercle is stronger in the left valve than in the right. The characters of the marginal area, muscle-scar pat-

tern and hinge structure are similar to the other species of this genus. Viewed from the inside the carapace is shallow; in dorsal view, it is compressed and broadest at the ventral projection of the second posterior ridge. The dorsal surface of the valves makes a small V-shaped trough. In anterior view, the carapace appears almost square owing to the blunt ventral projection of the second posteroventral ridge and the posterodorsal complex of surface ornamentations. Sexual dimorphism is not very strong. The male form is more slender than the female form.

Dimensions:—Holotype (male complete carapace) length 0.50 mm., height 0.28 mm., thickness 0.20 mm.; allotype (female complete carapace) length 0.50 mm., height 0.29 mm., thickness 0.21 mm.; paratypes (male complete carapace) length 0.47 mm., height 0.27 mm., thickness 0.19 mm.; (female complete carapace) length 0.51 mm., height 0.30 mm., thickness 0.22 mm.

Occurrence: All type specimens were collected from Recent beach sand at the shore back of an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are common. (coll. by T. HANAI, 3/11 1952)

Remarks: The quadrangular outline and blunt undulated ridges of this species show some resemblance to those of *Callistocythere undulatifacialis* HANAI. However, in detail, this species differs somewhat from *Callistocythere undulatifacialis* HANAI in surface ornamentation, especially in the second posterior marginal ridge, and in lacking reticulations, as well as being smaller.

Callistocythere hayamensis HANAI, n. sp.

Pl. VII, figs. 2a–d.

Description:—Carapace large, subquadrangular in side view. Anterior margin obliquely rounded, with about six small projections at the terminations of the radial pore canals along the lower half of the anterior margin. Ventral and dorsal margin nearly parallel. Ventral margin slightly sinuous in front of middle. Posterior cardinal angle distinct. Posterior margin rounded below. Surface sculptured by irregular and incomplete reticulations not well developed in marginal area. Reticulate surface slightly undulated. Weak ventral marginal ridge runs along anterior half of ventral margin.

Anterior marginal ridge strong; it begins in the upper margin, digresses slightly from the anterior middle of the margin, and ultimately connects with the ventral ridge. Dorsal ridge runs close to posterodorsal margin, and is high enough to obscure hinge line in side view. Second posterior marginal ridge very strong, consisting of two parts, one of which begins at posterior part of dorsal margin and ends in posterocentral area, where the other ridge occurs and runs toward ventral sinuous margin making a convex curve posteroventrally. This ridge has two pits at the place where the two ridges meet, and it has also a knob in the posteroventral area. Eye spot large and well developed, with a well polished surface. Marginal area, hinge structure, and muscle-scar pattern similar to other species of this genus.

Viewed from above, carapace compressed and sub-hexagonal, with second posterior marginal ridge projecting. Dorsal flat surfaces of each valves make a V-shaped trough along hinge line. Each flattened area crossed by about four transverse ridges making a reticulate pattern. Sexual dimorphism strong, female form more elongate than male.

Dimensions:—Holotype (male complete carapace) length 0.60 mm., height 0.31 mm., thickness 0.25 mm.; allotype (female complete carapace) length 0.58 mm., height 0.33 mm., thickness 0.25 mm.; paratypes (male complete carapace) length 0.61 mm., height 0.32 mm., thickness 0.25 mm.; (female complete carapace) length 0.58 mm., height 0.32 mm., thickness 0.25 mm.

Occurrence:—All type specimens were collected from the shore back of an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are common. (coll. by T. HANAI, 3/11 1952)

Remarks:—This species has a very close resemblance to *Callistocythere undulatifacialis* HANAI in its size, its outline, and even in its ornamentation. However, the incomplete reticulation, and the pits on the second posterior ridge of this species are characteristics which are not developed on the carapace of *Callistocythere undulatifacialis* HANAI. The two species may be easily confused. However, about 30 specimens of both species at hand do not show any transitional nature.

Callistocythere undulatifacialis HANAI, n. sp.

Pl. VII, figs. 3a–d, Pl. X, fig. 6.

Description:—Lateral outline of carapace similar to that of *Callistocythere hayamensis* HANAI. Surface sculptured by irregularly undulated ridges which have a tendency to run vertically in dorsal area and more or less transversely in ventral area of carapace. Subcentral tubercle prominent. Reticulations developed very poorly in anterocentral and ventrocentral areas. Ventral ridge and anterior marginal ridge similar to those of *Callistocythere hayamensis* HANAI. Second posterior marginal ridge begins in posterior part of dorsal margin and continues to middle of ventral margin. There is a knob-like swelling on it at the posteroventral corner. Marginal area, hinge structure, muscle-scar pattern and eye spot similar to those of other species of this genus. Dorsal and anterior views and sexual dimorphism similar to those of *Callistocythere hayamensis* HANAI.

Dimensions:—Holotype (male complete carapace) length 0.60 mm., height 0.32 mm., thickness 0.23 mm.; allotype (female complete carapace) length 0.57 mm., height 0.32 mm., thickness 0.25 mm.; paratypes (male complete carapace) length 0.61 mm., height 0.32 mm., thickness 0.25 mm.; (female complete carapace) length 0.57 mm., height 0.32 mm., thickness 0.25 mm.

Occurrence:—All type specimens were callected from Recent beach sand at the shore back of an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are common. (coll. by T. HANAI, 3/11 1952)

Remarks:—This species is characterized by the irregularly undulating ridges, sub-central tubercles and very poorly developed reticulations on the external surface. The differences between this species and *Callistocythere rugosa* are given in the discussion of that species.

Callistocythere subjaponica HANAI, n. sp.

Pl. VIII, figs. 4a–e.

Description:—Carapace subquadrangular to subreniform, somewhat tumid, highest at anterocardinal angle. Anterior margin smooth,

broadly and obliquely rounded. Dorsal margin nearly straight. Posterior cardinal angle distinct. Posterior margin truncated above, rounded below. Ventral margin sinuous near middle. Surface sculptured by low undulating ridges, which have a tendency to run vertically in dorsal area and more or less transversely in ventral area of carapace. Anterior marginal ridge begins at upper part of anterior margin and continues to anteroventral margin. It digresses from anterior margin in its upper half. Second posterior marginal ridge occurs at posterior part of dorsal margin, runs nearly parallel to posterior margin and ends at posteroventral margin. In dorsal view, sides nearly straight; anterior end more pointed than posterior, and marginal ridges project slightly near each end. In end view, carapace subovate, broadest at point near mid-height; ventral outline somewhat flattened. Marginal area, hinge structure, and adductor muscle-scar pattern similar to those of other species of this genus. However, in this species, the crenulation of the anterior tooth of the right valve is more pronounced than in other Japanese species. A weak vestibule is restricted to anterior and anteroventral areas. Sexual dimorphism strong; female form larger and higher than male form, and shows more or less subquadrangular lateral outline. In dorsal view, female form appears broader than male especially in posteroventral area.

Dimensions:—Holotype (male complete carapace) length 0.55 mm., height 0.30 mm., thickness 0.23 mm., allotype (female complete carapace) length 0.57 mm., height 0.32 mm., thickness 0.26 mm.; paratype (male complete carapace) length 0.50 mm., height 0.29 mm., thickness 0.23 mm.

Occurrence:—All type specimens were collected from Recent beach sand at the shore back of an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are common. (coll. by T. HANAI, 3/11 1952)

Remarks:—The surface ornamentation as well as the tumid and somewhat cylindrical shape of the carapace of this species suggest some affinity to the *Callistocythere japonica* group. However, this species is shorter than *C. japonica* and, furthermore, the two teeth of almost equal size at the anterior termination of the intermediate bar of the left valve of this species are a characteristic of *Callistocythere littoralis* group hinge structure.

Callistocythere setanensis HANAI, n. sp.

Pl. X, figs. 3a, b.

Description:—Carapace comparatively large and thick, subquadrangular in side view, highest at anterior cardinal angle; anterior margin obliquely rounded, dorsal margin slightly arched, ventral margin nearly straight, posterior margin truncated above and rounded below. Surface ornamented by reticulations; two anterior and two posterior marginal ridges prominent. Strong ventral ridge starts in anteroventral area, runs parallel to ventral contact margin, and ends at posteroventral area, where it becomes a characteristically large, coarsely reticulate node. Marginal area, hinge structure, muscle-scar pattern similar to those of other species of this genus. In dorsal view, carapace compressed and subhexagonal; in anterior view, subovate.

Dimensions:—Holotype (left valve) length 0.86 mm., height 0.46 mm.; paratype (right valve) length 0.85 mm., height 0.46 mm.

Occurrence:—All type specimens were collected from the Upper Pliocene Setana formation in the valley of Toshibetsu-gawa, about 800 m. W. of Omagari, Toshibetsu-mura, Setana-gun, Hokkaido, where it is rare.

Remarks:—This species is one of the rare cold-water *Callistocythere*. A coarsely reticulated node in the posteroventral area of the carapace is the most distinctive character of this species.

2. *Callistocythere japonica* group.

Carapace comparatively thin, tumid or cylindrical, and elongate. Dentition similar to that of *Callistocythere littoralis* group, but first anterior terminal tooth and socket structure of intermediate element enlarged, and second anterior terminal tooth and socket structure diminished. Vestibule moderate. Color yellow.

Callistocythere japonica HANAI, n. sp.

Pl. IX, figs. 2a–g; text-figs. 1, B, C; 2, E, F.

Description:—Carapace elongate subreniform, somewhat tumid and subcylindrical. Anterior margin smooth, rounded obliquely.

Dorsal margin slightly convex; ventral margin slightly concave, nearly parallel to dorsal. Posterior cardinal angle distinct, marked by posterior hinge tubercle. Posterior margin subtruncate above and rounded below. Surface sculptured by low undulating ridges which have a tendency to run obliquely forward. Small scale reticulation develops between ridges in posterocentral and ventrocentral areas. Marginal ridge occurs along posterior half of ventral margin and tends to obscure it. Second anterior marginal ridge appears near anteroventral margin, and runs along anterior margin to anterocardinal angle, being especially strong in upper half. Dorsoposterior marginal ridge starts near eye spot and is sufficiently high to obscure the straight hinge line. It reaches the lower part of the posterior margin. Second posterior marginal ridge begins in front of posterior cardinal angle and extends in an arc to middle of ventral margin. It is very strong in the posterodorsal area. In dorsal view, carapace elongate arrowhead-shaped, pointed in front; sides nearly straight; posterior end notched. Dorsal surface of valves forms a V-shaped trough along hinge line. In anterior view, carapace appears nearly round. Flange departs from posterior extremity so as to form an apparent opening when carapace is viewed from posterior. Marginal areas and muscle-scar pattern are similar to other species of this genus. At posterocardinal angle, hingement and flange of posterior marginal area meet at posterior tooth to form almost a right angle. A moderate vestibule is restricted to anterior and anteroventral areas. Sexual dimorphism strong. Female form broader in posterocentral area and more tumid in anterior view than male form. Surface sculpture of male stronger than that of female, especially in posteroventral area.

Dimensions:—Holotype (male complete carapace) length 0.60 mm., height 0.28 mm., thickness 0.24 mm.; allotype (female complete carapace) length 0.63 mm., height 0.32 mm., thickness 0.28 mm.; paratypes (male complete carapace) length 0.61 mm., height 0.30 mm., thickness 0.24 mm.; (female complete carapace) length 0.58 mm., height 0.30 mm., thickness 0.25 mm.

Occurrence:—All type species were collected from Recent beach sand from the shore back of an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are common.

Remarks:—This species is distinctive in its tumid, cylindrical,

elongate form. Furthermore, the apparent opening at the posterior end is a characteristic feature of this species. A species described by CHAPMAN (1914, Melbourne Proc. Roy. Soc. Vict., new series, 27, p. 33, pl. 6, fig. 9) as *Cythere crispata* has an outline somewhat similar to that of this species. However, the ornamentation and the shape of the posterior margin of CHAPMAN's species are quite different from those of *Callistocythere japonica* HANAI.

Callistocythere japonica uranipponica HANAI, n. subsp.

Pl. IX, figs. 3a-c.

Description:—*Callistocythere japonica* with quadrangular outline. Posterior cardinal angle distinct, posterior margin truncated and rather narrowly rounded off below. Flange runs along posterior margin. No distinct posterior notch in dorsal view, i. e., no distinct apparent opening in posterior view.

Dimensions:—Holotype (male complete carapace) length 0.64 mm., height 0.34 mm., thickness 0.27 mm.; paratype (left valve) length 0.61 mm., height 0.32 mm., thickness 0.25 mm.

Occurrence:—All type specimens were collected from Recent beach sand from the shore of Kashiwara, about 200 m. S. E. of Dozanto-to, near Yamaga, Ashiya-machi, Onga-gun, Fukuoka Prefecture.

Remarks:—Because it has the same ornamentation, this form is considered to be a subspecies of *C. japonica*. *Callistocythere japonica* s. str. appears to be restricted to the Pacific coast of Japan.

Callistocythere pumila HANAI, n. sp.

Pl. X, figs. 2a-c.

Description:—Carapace small, elongate subreniform, tumid, subcylindrical. Anterior margin obliquely rounded. Dorsal margin slightly arched, nearly parallel to slightly concave ventral margin. Posterior cardinal angle distinct. Posterior margin truncated above, broadly rounded below. Surface ornamented by irregularly undulated ridges which have a tendency to run obliquely in dorsal half and parallel to ventral margin in ventral half. Reticulate pattern develops between ridges in posterior half of carapace. Two anterior marginal ridges prominent, one running from upper part of anterior

margin to anteroventral margin, other starting at anterior cardinal angle, bifurcating at middle and running into anterior part of ventral margin making a convex curve anteriorly. Sulcus-like depression obliquely notched into posteroventral area. Characters of hinge structure, marginal area, and adductor muscle scar pattern similar to other species of the *Callistocythere littoralis* group. Front terminal tooth and socket structure of intermediate element of both valves distinct; second tooth and socket structure obscure. "Snap-knob" and "pit" structure present. In dorsal view, carapace elongateovate. Dorsal surface of valves forms a V-shaped trough along hinge line.

Dimensions:—Holotype (complete carapace) length 0.49 mm., height 0.25 mm., thickness 0.21 mm.; paratype (complete carapace) length 0.46 mm., height 0.24 mm., thickness 0.19 mm.

Occurrence:—All type specimens were collected from Recent beach sand from the shore about 1 km. N. E. of Akase railroad station, near Hiraiwa, Auda-mura, Uto-gun, Kumamoto Prefecture.

Remarks:—At the type locality there are a number of specimens of this species which have greatly reduced ornamentation; this is probably the result of partial digestion by some other animals.

3. *Callistocythere minor* group

Carapace thick with compressed anterior margin and characteristic posteroventral projection. Hinge "merodont" with containant. Anterior and posterior tooth-and-socket structure distinct. Median element not differentiated into two-fold elements. Line of concrescence almost coincides with inner margin. Color usually yellow.

This group is closely related to *Callistocythere setanensis* HANAI. It differs especially in hinge structures. The species described by POKORNY (1952) as *Leptocythere lacunosa* (REUSS) has a similar hingement. It is at present difficult to conclude that "merodont" type hingement is phylogenetically older than the other type of hingement in Leptocytherinae, in spite of the fact that the young molt of the *Callistocythere* has a "merodont" "*Archicythereis*" type hingement.

Callistocythere minor HANAI, n. sp.

Pl. X, figs. 1a–e; text-figs. 2, A, B.

Description:—Carapace thick, small elongate and subquadrangular in lateral outline. Anterior margin broadly and obliquely rounded, dorsal margin straight and long, inclined slightly toward posterior, ventral outline straight, nearly parallel to dorsal margin. Posterior margin truncated obliquely in upper half and lower half so as to make blunt angulation at mid-height. Carapace compressed along anterior margin. Surface ornamented with irregularly undulated ridges. Ridges prominent in ventral and posteroventral areas; a prominent ridge projects in broad V-shape surrounding a very deep depression in the posteroventral area. In dorsal view, sides nearly parallel. Carapace slightly constricted in central adductor-muscle area; however, place of muscle-scar attachment slightly protruded.

Marginal area moderately broad in anterior and posteroventral areas. Radial pore canals polyfurcated. Hingement of right valve consists of an anterior crenulated tooth, an intermediate smooth to faintly crenulate bar and a posterior distinct and crenulate tooth. Hingement of left valve consists of anterior socket, intermediate faintly crenulate bar, and posterior socket. Both sockets connected by a containant just above intermediate bar and below flange. Sockets open interiorly. Teeth of anti-slip nature develop in front of anterior socket and behind posterior socket. In right valve, faintly crenulate shelves develop just below anterior and posterior terminal parts of intermediate bar so as to receive high and strong anterior and posterior parts of median bar of left valve. Adductor muscle scars a little below center; at least four scars in a vertical row. "Snap knob-and-pit" structure obscure.

Dimensions:—Holotype (a complete carapace) length 0.42 mm., height 0.21 mm., thickness 0.16 mm.; paratypes (a complete carapace) length 0.41 mm., height 0.19 mm., thickness 0.15 mm.; (a complete carapace) length 0.39 mm., height 0.18 mm., thickness 0.14 mm.

Occurrence:—All type specimens were collected from Recent beach sand from Toura, Hamazaki-mura, Kamo-gun, Shizuoka Prefecture, where they are common.

Genus TANELLA Kingma, 1948

1948 *Tanella* Kingma, pp. 87, 88.

Type Species:—Tanella gracilis Kingma, 1948.

Diagnosis:—Carapace elongate and tumid; surface sculptured by reticulations and ridges. Anterior tooth of right valve replaced by elongate swelling of dorsal edge. In left valve, anterior socket lacking; anterior tooth of median bar represented by a strong anti-slip tooth.

Description:—Carapace rather small, thin and oblong in outline. Surface ornamented by reticulations and ridges; anterior and posterior marginal ridges prominent. Hingement of right valve consists of elongate teeth which project slightly interiorly; an intermediate bar and a posterior crenulate tooth which is distinctly arched posterodorsally. Hingement of left valve consists of a posterior socket, an intermediate crenulate ridge with a distinct anti-slip tooth at its anterior end, and a posterior crenulate socket which opens interiorly. A containant develops just above the intermediate bar and the anti-slip tooth; the containant becomes deeper just above the anti-slip tooth to retain the elongate anterior teeth of the opposite valve. Containant opens interiorly just in front of and just behind the anti-slip tooth. The anti-slip tooth fits between the two or more very elongate anterior teeth of the right valve. Duplicature moderate, widest at anteroventral area where sometimes a vestibule is present. Radial pore canals typically polyfurcate. Ventral sinuous margin of right valve has a "snap-knob" and the left valve has a "snap-pit" as previously described for *Callistocythere*. Adductor muscle-scar pattern consists of four scars in one vertical row and two in front of them. Sexual dimorphism very strong; female forms having inflated carapace.

Tanella miurensis Hanai, n. sp.

Pl. IX, figs. 1a–e; text-figs. 2, I, J.

Description:—Carapace thin, oblong and tumid, highest slightly posterior to anterior cardinal angle. Anterior margin obliquely rounded. Dorsal margin nearly straight, inclined toward posterior.

Ventral margin straight, slightly sinuous at anterior end. Posterior margin truncated above, narrowly rounded below. Surface sculptured by reticulations, each reticulation consisting of about two to four deep pits. Pits coarse in anterocentral area. Anterior marginal ridge strong; beginning at anterocardinal angle and ending in anteroventral area. Posterior marginal ridge strong, beginning in posterior part of dorsal margin and extending in an arc to posteroventral area, becoming straight and running parallel to ventral margin to ventral sinuous area. Shallow, vertical, median sulcus in dorsocentral area just above muscle-scar area. Hinge structure typical of genus; anterior half of hinge line arched, posterior half straight. Marginal area and adductor muscle-scar pattern same as for genus. Viewed from above, carapace ovate with anterior and posterior marginal ridges projecting. Dorsal flat area of valves makes a V-shaped trough along posterior half of hinge margin. In end view, carapace subovate. Sexual dimorphism very strong. In side view, posterior cardinal angle of female form less than 90°, that of male more than 90°. Viewed from above, female form much more inflated than male; thickest part of carapace near center in male form, but well to posterior in female form.

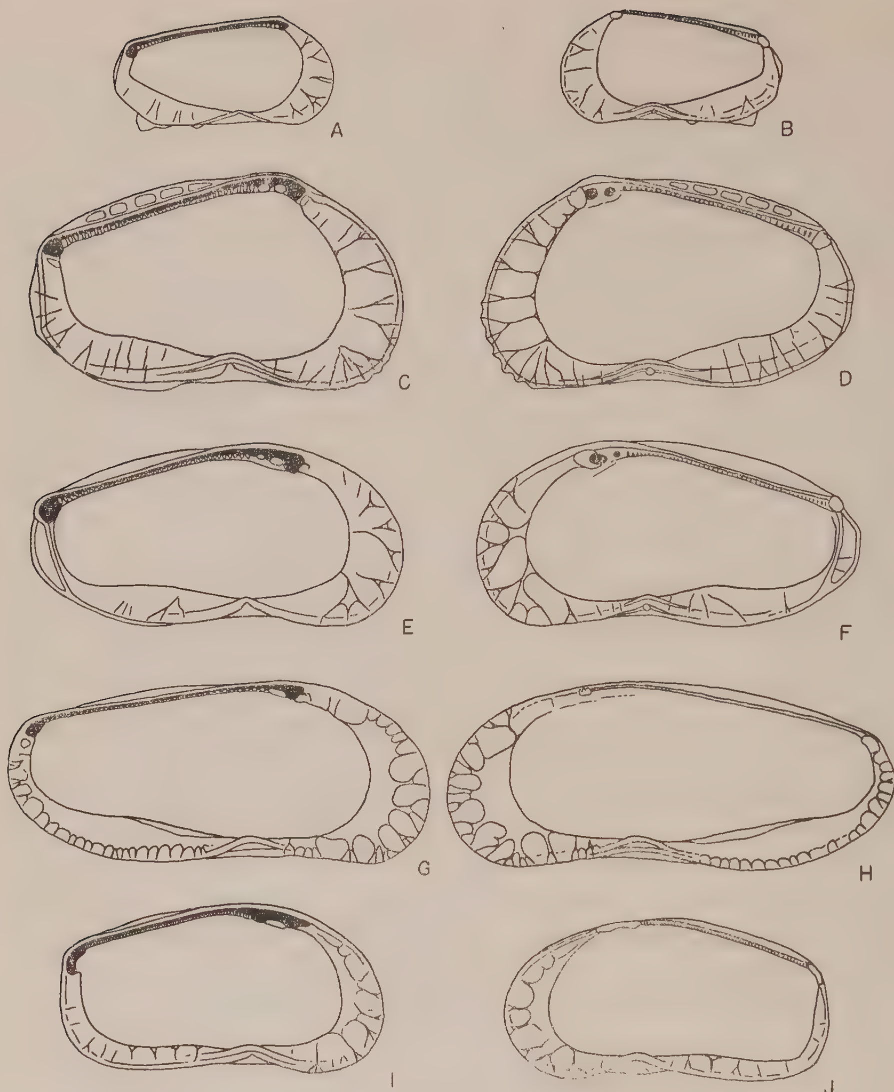
Dimensions:—Holotype (male complete carapace) length 0.56 mm., height 0.28 mm., thickness 0.22 mm.; allotype (female complete carapace) length 0.60 mm., height 0.32 mm., thickness 0.28 mm.; paratype (male complete carapace) length 0.56 mm., height 0.28 mm., thickness 0.23 mm.

Occurrence:—All type species were collected from Recent beach sand from the shore behind an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are rare.

Comparison:—This species differs from *Tanella gracilis* KINGMA in 1) the development of a vestibule, 2) a shorter outline, 3) the crenulation of the intermediate bar of the right valve, and 4) two elongate anterior teeth of the right valve which are represented by an elongate tooth in *Tanella gracilis*.

Conclusions

The phylogenetic relationships in the subfamily Leptocytherinae are at present difficult to determine with certainty. However, the



Text-figure 2, Diagrams showing morphological relations between leptocytherid Ostracods.

A, B. *Callistocythere minor* HANAI, n. sp.
C, D. *Callistocythere nipponica* HANAI, n. sp.
E, F. *Callistocythere japonica* HANAI, n. sp.
G, H. *Leptocythere pellucida* (BAIRD), 1850
I, J. *Tanella miurensis* HANAI, n. sp.

following morphological relationships in the dentition have been ascertained.

1) The simplest hingement found in Leptocytherinae seems to be crenulated "merodont" with containant. (example: *Callistocythere minor* group).

2) A modification is found in the *Callistocythere littoralis* and its allies, whose dentition is entomodont.

3) A further modification is the diminution of the second anterior tooth-and-socket structure of the intermediate element as exemplified by the *Callistocythere japonica* type.

4) Another modification is the disappearance of the intermediate element of the right valve from the *Callistocythere* type dentition, and the development of anti-slip teeth from the anterior teeth of the intermediate element of the left valve, together with suppression of the crenulation of the intermediate element of right valve, as in *Leptocythere* (s. str.).

5) Finally, reduction of the anterior tooth-and-socket structure of both valves and development of a strong anti-slip tooth in the left valve is characteristic of the *Tanella* type.

The subfamily as described above has a rather gradationally variable dentition; however, all genera possess a posterior tooth-and-socket structure and a containant.

Postscript:—After this manuscript was completed the writer found that the *Tanella miurensis* HANAI is identical with *Cythere inflata* described by BRADY (1890) from the south sea islands (Fiji and Samoa). The name *Cythere inflata* has, however, been preoccupied by *Cythere inflata* MÜNSTER 1830, *Cythere inflata* M'COY 1862, *Cythere (Bairdia) inflata* NORMAN 1862, and *Cythere inflata* TERQUEM 1878. Therefore BRADY'S *Cythere inflata* needs a new name. Since BRADY'S *Cythere inflata* belongs to genus *Tanella*, the writer hereby proposes a new name *Tanella pacifica* for *Cythere inflata* BRADY (1890, pp. 498–499, pl. II, figs. 8, 9). In conclusion, *Tanella miurensis* HANAI of this paper is not a new species and should read *Tanella pacifica* HANAI, new name.

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Studies on the Ostracoda from Japan

I. Subfamily Leptocytherinae n. subfam.

Plate VII

Explanation of Plate VII

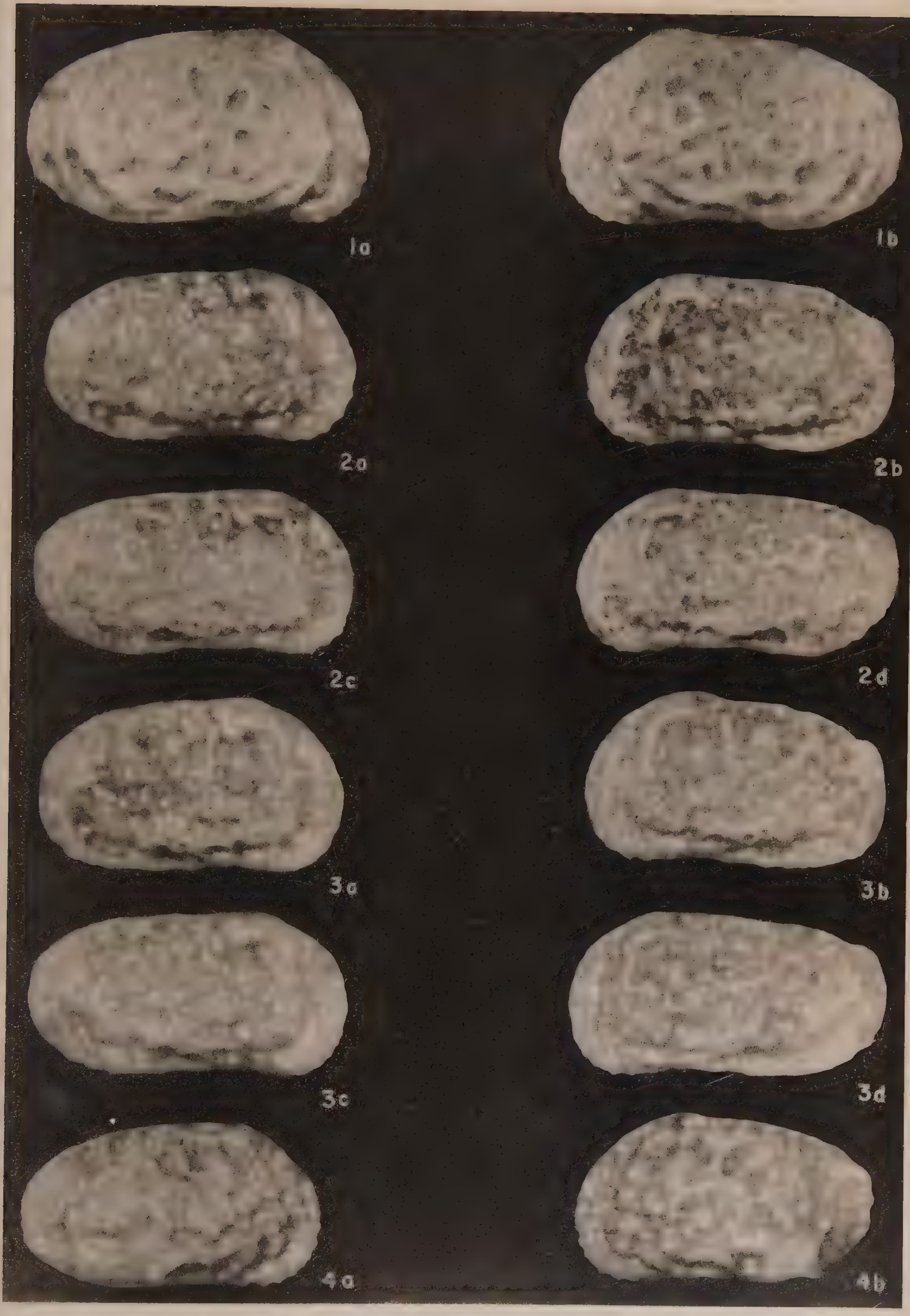
All figures $\times 88$

Figs. 1a, b. *Callistocythere nipponica* HANAI, n. sp. 446
1a, right valve view of holotype (CA 2541).
1b, left valve view of holotype.

Figs. 2a–d. *Callistocythere hayamensis* HANAI, n. sp. 453
2a, right valve view of allotype (CA 2549).
2b, left valve view of allotype.
2c, right valve view of holotype, (CA 2548).
2d, left valve view of holotype.

Figs. 3a–d. *Callistocythere undulatifacialis* HANAI, n. sp. 455
3a, right v lve view of allotype (CA 2563).
3b, left valve view of allotype.
3c, right valve view of holotype (CA 2562).
3d, left valve view of holotype.

Figs. 4a, b. *Callistocythere alata* HANAI, n. sp. 450
4a, right valve view of holotype (CA 2547).
4b, left valve view of holotype.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4b

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Studies on the Ostracoda from Japan

I. Subfamily Leptocytherinae n. subfam.

Plate VIII

Explanation of Plate VIII

All figures ×88

Figs. 1a–d. *Callistocythere undata* Hanai, n. sp. 452
1a, right valve view of holotype (CA 2554).
1b, left valve view of holotype.
1c, right valve view of allotype (CA 2555).
1d, left valve view of allotype.

Figs. 2a–d. *Callistocythere reticulata* Hanai, n. sp. 448
2a, right valve view of holotype (CA 2543).
2b, left valve view of holotype.
2c, right valve view of allotype (CA 2544).
2d, left valve view of allotype.

Figs. 3a–d. *Callistocythere rugosa* Hanai, n. sp. 451
3a, right valve view of holotype (CA 2550).
3b, left valve view of holotype.
3c, right valve view of allotype (CA 2551).
3d, left valve view of allotype.

Figs. 4a–e. *Callistocythere subjaponica* Hanai, n. sp. 455
4a, right valve view of holotype (CA 2566).
4b, left valve view of holotype.
4c, right valve view of allotype (CA 2567).
4d, left valve view of allotype.
4e, dorsal view of holotype.


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3a
1c
1d
3b
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3c
2c
2d
3d
4a
4b
4e
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4d

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Studies on the Ostracoda from Japan

I. Subfamily Leptocytherinae n. subfam.

Plate IX

Explanation of Plate IX

All figures ×88

Figs. 1a–e. *Tanella miurensis* HANAI, n. sp. 462
1a, right valve view of holotype (CA 2582).
1b, left valve view of holotype.
1c, right valve view of allotype (CA 2583).
1d, left valve view of allotype.
1e, dorsal view of allotype.

Figs. 2a–g. *Callistocythre japonica* HANAI, n. sp. 457
2a, right valve view of holotype (CA 2572).
2b, left valve view of holotype.
2c, right valve view of allotype (CA 2573).
2d, left valve view of allotype.
2e, right valve view of paratype (CA 2575).
2f, left valve view of paratype (CA 2575).
2g, dorsal view of holotype.

Figs. 3a–c. *Callistocythere japonica uranipponica* HANAI, n. subsp. 459
3a, right valve view of holotype (CA 2576).
3b, left valve view of holotype.
3c, dorsal view of holotype.


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1d
2a
2g
2b
2c
2d
2e
3c
2f
3a
3b

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Studies on the Ostracoda from Japan

I. Subfamily Leptocytherinae n. subfam.

Plate X

Explanation of Plate X

All figures ×88

Figs. 1a–e. *Callistocythere minor* HANAI, n. sp. 461
1a, right valve view of paratype (CA 2586).
1b, left valve view of paratype (CA 2587).
1c, right valve view of holotype (CA 2585).
1d, left valve view of holotype.
1e, dorsal view of holotype.

Figs. 2a–c. *Callistocythere pumila* HANAI, n, sp. 459
2a, left valve view of paratype (CA 2579).
2b, right valve view of holotype (CA 2578).
2c, right valve view of paratype (CA 2581).

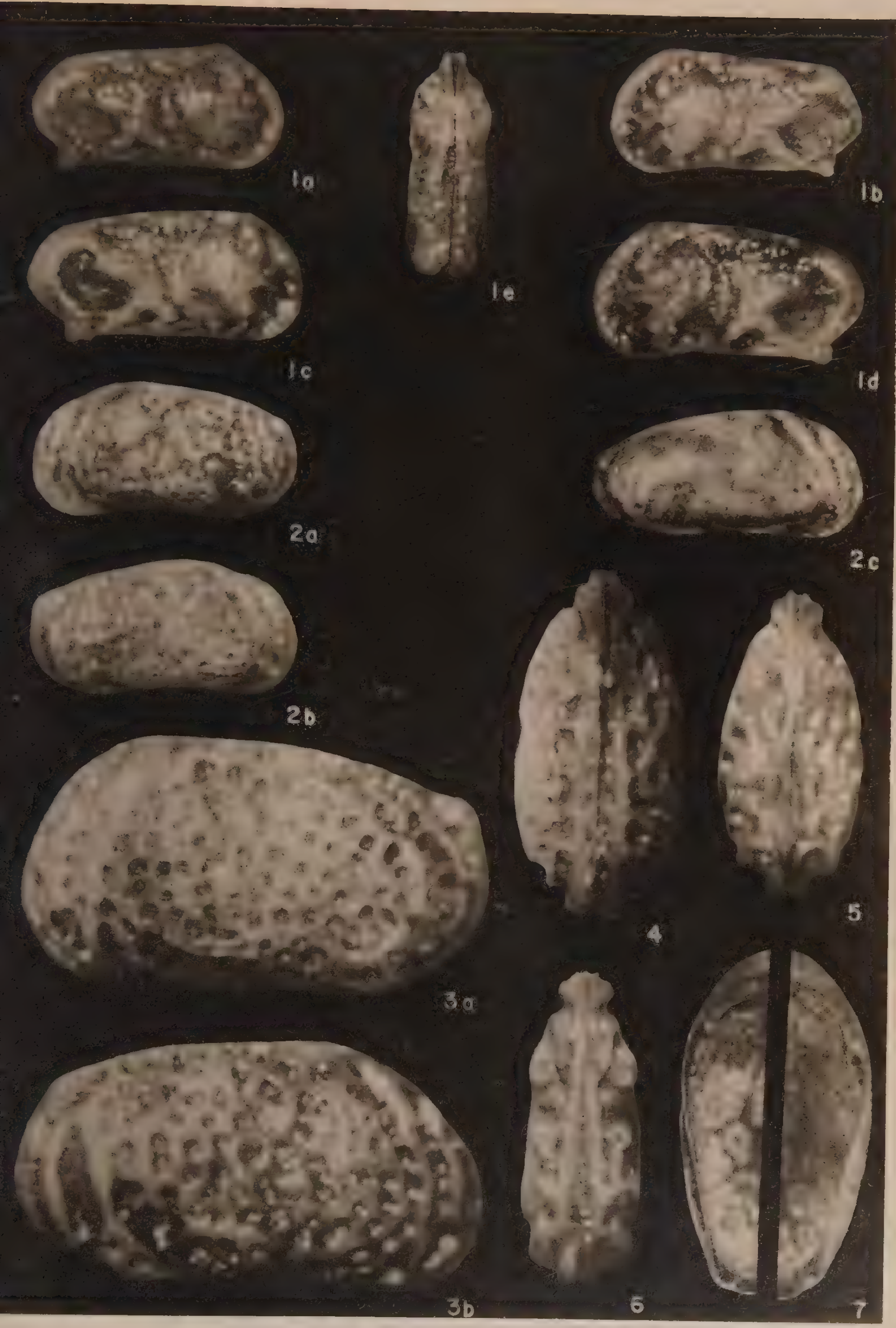
Figs. 3a, b. *Callistocythere setanensis* HANAI, n. sp. 457
3a, left valve view of holotype (CA 2570).
3b, right valve view of paratype (CA 2571).

Fig. 4. *Callistocythere nipponica* HANAI, n. sp. 446
dorsal view of holotype (CA 2541).

Fig. 5. *Callistocythere alata* HANAI, n. sp. 450
dorsal view of holotype (CA 2547).

Fig. 6. *Callistocythere nndulatifacialis* HANAI, n. sp. 455
dorsal view of holotype (CA 2562).

Fig. 7. *Callistocythere japonica* HANAI, n. sp. 457
Hinge structure of left and right valves of paratype (CA 2636).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Studies on the Ostracoda from Japan

II. Subfamily Pectocytherinae n. subfam.

By

Tetsuro HANAI

Abstract

This is the second paper of basic taxonomic studies of Ostracoda found living in the sea surrounding Japan and as fossils in Neogene and Quaternary deposits in Japan. Modified "merodont" hingement with teeth at the anterior and posterior terminations of the median bar of the left valve (Pentodont, new name) characterizes a group of Ostracoda which is here described as Pectocytherinae n. subfam. This subfamily include at least three genera; *Pectocythere* n. gen., "*Toulminia*" MUNSEY, and *Arcacythere* HORNIBROOK. The Japanese samples contained two new species of *Pectocythere* and two new species of "*Toulminia*".

Table of Contents

Introduction

The Pectocytherinae n. subfam. are less common and less well known in Japan and vicinity; however, they occur very abundantly in some localities. This group of ostracods has not yet been studied in detail because of the small size of the carapace. Two species, *Arcacythere chapmani* HORNIBROOK from the Lillburian (Middle Miocene) of New Zealand and "*Toulminia*" *hyalokystis* (MUNSEY) from the Coal Bluff member of the Naheola formation (Paleocene) of the Gulf Coastal Plain of the United States, are the only ones which have so far been described properly and considered to belong to the subfamily Pectocytherinae. Modified "merodont" hingement with

teeth at the anterior and the posterior terminations of the median bar of the left valve (Pentodont, new name), as well as the nature of the marginal area and a thick circumscribed ridge on the surface of the carapace, characterizes this subfamily. I have had available for study Paleocene topotype specimens of "*Toulminia*" *hyalokystis* MUNSEY, the type species, and found that Japanese Recent and Plio-Pleistocene specimens of "*Toulminia*" show striking resemblance to American Paleocene species, in spite of the difference in geologic age. Another group of Japanese Pectocytherinae n. subfam. deviates from the type "*Toulminia*" in shell stucture. I, therefore, propose the name *Pectocythere* for this group of Ostracoda, and select this genus as the type of the new subfamily. In this paper two new species of *Pectocythere*, and two new species of "*Toulminia*" are described from the Japanese area.

Acknowledgements

Preliminary studies on these Ostracoda were initiated at the University of Tokyo. I am deeply indebted to Prof. Teiichi KOBAYASHI and Prof. Takao SAKAMOTO for guidance and continued encouragement.

This paper was completed in the United States under the direction of Prof. H. V. HOWE, Director, School of Geology, Louisiana State University. I am deeply indebted to Dr. HOWE for his helpful suggestions and criticisms and for access to his type collections and his library.

Mr. R.L. ARTUSY of Houston, Texas, Mr. Andrew W. MARIANOS of the Humble Oil and Refining Co., Chico, California, and Mr. P.C. SYLVESTER-BRADLEY of the University of Sheffield, England, have contributed helpful suggestions. Finally the manuscript was edited by Mr. A. H. CHEETHAM of Louisiana State University. To all of these people, I should like to express my deep gratitude.

Repositories of type specimens

All holotypes and some paratypes are deposited in the type collection of the Geological Institute, University of Tokyo, Tokyo, Japan, and the other paratypes are deposited in the H. V. HOWE Collection, School of Geology, Louisiana State University, Baton

Rouge, Louisiana, U. S. A.

Systematic Descriptions

Family Cytheridae BAIRD, 1850

Subfamily Pectocytherinae HANAI, n. subfam.

Type Genus:—Pectocythere HANAI, n. gen.

Diagnosis :—Carapace small and thick, subquadrangular in lateral outline. Surface coarsely punctate and/or ornamented with undulated ridges, and having marginal ridges tending to circumscribe periphery of carapace. Marginal area broad. Vestibule develops along anteroventral margin. Radial pore canals simple, straight, and few. Hinge modified "merodont" or pentodont. Left valve hingement consists of anterior and posterior sockets which open interiorly, and a median crenulate bar between. Anterior and posterior terminations of median bar swell into knob-like projections, one at each end (anteromedian and posteromedian teeth). Right valve with two terminal teeth and a median groove between. Anterior and posterior terminations of median groove widened and deepened to form sockets, one at each end.

Description :—Shape and ornamentation variable; however, ridges tend to circumscribe margin of carapace, being especially strong along anterior margin and obscure along posteroventral margin. In thick-shelled species, the marginal ridge becomes obscure; but the marginal area becomes very thick owing perhaps to the fusion of the marginal ridge and the carapace. Left valve tends to overlap right at anterodorsal corner. Normal pore canals large, few, and scattered. Adductor muscle-scar pattern consists of four vertical scars and at least one scar anterior.

Remarks :—The subfamily Pectocytherinae which has an outline similar to that of the subfamily Leptocytherinae. The main difference between the two subfamilies is the presence in the Leptocytherinae of polyfurcated radial pore canals and of a containant structure in the hingement. Some genera of the subfamily Cytherurinae, i. e., genus *Tetracytherura* RUGGIERI, 1952, include the species which have a median bar in the left valve terminated at each end by small tooth-like projections. However, in the other characteristics, including the details of hinge structure, the Cytherurinae do

not show close relationship to the Pectocytherinae. In the Pectocytherinae the anterior and posterior tooth-like projections of the median bar in the left valve are not simple as in the Cytherurinae, but consist of two parts, each with upper and lower elements.

The similarity in the shell structures, especially in the adductor muscle scar pattern and in the nature of the marginal area, suggests that the Pectocytherinae are closest in relationship to the subfamily Eucytherinae PURI, 1953. However, the toothless hinge structure of the Eucytherinae which articulates by means of non-crenulate groove and flange is different from the pentodont hingement characteristic of the Pectocytherinae. Contrary to toothless *Eucythere* from the Gulf Coast of the United States, *Eucythere* described by HORNIBROOK from New Zealand has a weakly developed hinge structure. However, its median element does not differentiate into any subdivisions and, moreover, the anterior and posterior terminal teeth and sockets are long and crenulated.

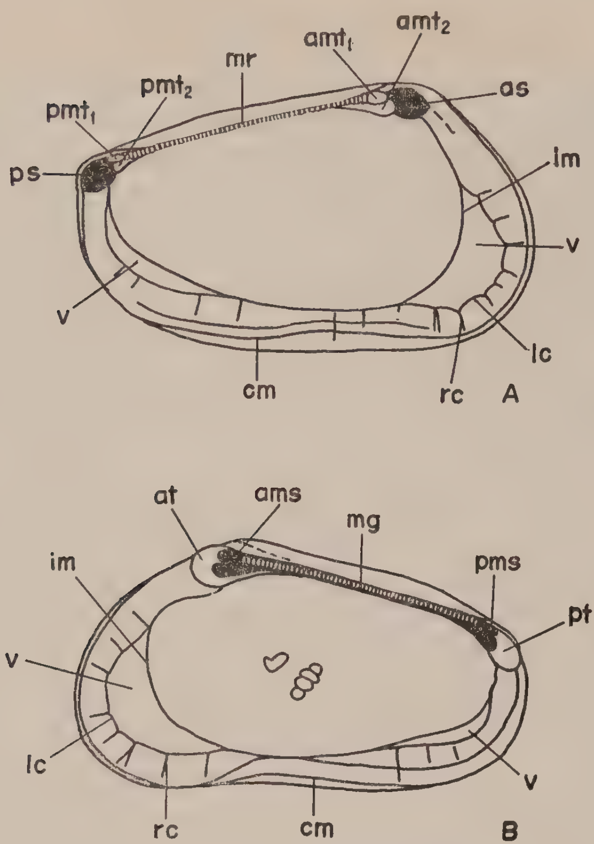
This subfamily includes the following genera:

Pectocythere HANAI, n. gen.
" *Toulminia* " MUNSEY, 1953
Arcacythere HORNIBROOK, 1953

According to HORNIBROOK (1953), the hingement of *Arcacythere* does not show any differentiation of the median element; however, its thick box-shaped carapace with circumscribed ridge and characteristic overlapping of left valve over right at the anterior cardinal angle suggests a close relationship of *Arcacythere* to *Pectocythere*.

Age:—The genus *Pectocythere* is so far known only from Pliocene deposits in Japan. According to HORNIBROOK (1952), *Arcacythere* ranges from Piripauan (Upper Cretaceous) to Waiauan (Middle Miocene) and occurs only in New Zealand. " *Toulminia* " is known in the Paleocene of the Gulf Coastal Plain of the United States and from the Pliocene to Recent of the Japanese coast[1].

1) I had an opportunity to study several subsurface samples from the northern Great Valley, California, through courtesies of Messrs. J. D. FRICK, A. W. MARIANOS and R. P. ZINGULA, of the Humble Oil and Refining Co., at Chico, California. As the result of the study it was found that some of the Eocene samples contain one new species of " *Toulminia* ".



Text-figure 1a, b. Structure of the pectocytherid carapace.

Key to terms

as: anterior socket
ps: posterior socket
at: anterior tooth
pt: posterior tooth
amt_1: upper element of anteromedian tooth
amt_2: lower element of anteromedian tooth
pmt_1: upper element of posteromedian tooth
pmt_2: lower element of posteromedian tooth
ams: anteromedian socket
pms: posteromedian socket
mr: crenulate median ridge
mg: crenulate median groove
im: inner margin
v: vestibule
lc: line of concrescence
rc: radial pore canals
cm: contact margin

Genus PECTOCYTHERE HANAI, n. gen.

Type Species:—Pectocythere quadrangulata HANAI, n. sp.

Diagnosis:—Very thick-shelled Pectocytherinae with oblong box-shaped carapace. Marginal area of carapace especially thick because of ridge which is extremely blunt and bold, having a tendency to circumscribe periphery of shell. Hingement pentodont, similar to that of other Pectocytherinae, but in left valve, lower non-crenulate elements of anteromedian and posteromedian teeth are larger than upper elements; both elements are well separated from each other. Along anteroventral margin, radial pore canals tend to be grouped in pairs, one of which opens nearer the contact margin than the other.

Description:—Nature of carapace outline and surface ornamentation are same as described in the diagnosis. Along anterior margin, a thin lip-like projection usually develops. Hingement is similar to "*Toulminia*", but differs in details mentioned in diagnoses. Anterior tooth and socket structure well developed in comparison with posterior. Marginal area broad anteriorly, vestibule well developed along anterior obliquely rounded margin and poorly along posteroventral margin. Radial pore canals few, and tending to be grouped in pairs, one of which opens nearer the contact margin than the other, along vestibule area. Normal pore canals few and scattered. Adductor muscle-scar pattern consists of a posterior vertical row of four scars and one anterior scar.

Remarks:—The box-shaped carapace shows close relationship to *Arcacythere* described by HORNIBROOK (1952) from the Cretaceous to Miocene of New Zealand, but the hinge structure is quite different. Moreover, the marginal ridge of *Pectocythere* is not so continuous as that of *Arcacythere* especially in the posteroventral area. "*Toulminia*" shows similar type of hinge structure, but in detail, the lower non-crenulate element of the anterior and posterior teeth in the left valve are larger than the upper element.

Pectocythere quadrangulata HANAI, n. sp.

Pl. XI, figs. 3a, b; text-figs. 6a, b.

Description:—Carapace small and extremely thick, box-shaped. Anterior margin broadly and obliquely rounded with thin lip-like

projection. Dorsal margin slightly arched, inclined toward posterior. Ventral margin nearly straight. Posterior margin truncated above and rounded below. Surface ornamented by scattered punctations, which are the openings of normal pore canals, and blunt thick ridges, which more or less circumscribe periphery of carapace, except anteroventral and posteroventral areas. One ridge starts in anteroventral area, runs posterioly obscuring middle part of ventral contact margin, and terminates in posteroventral area. Another ridge starts at mid-height of anterior area, runs upward along anterior margin, then circumscribes periphery of dorsal margin, and terminates in mid-height of posterior area, where ridge becomes extremely strong. A small ridge appears along rounded posteroventral margin. Ridges run along and close to anterior and posterior peripheries of carapace but do not quite reach peripheries. Open area inside of ridges also ornamented with complex of blunt and thick ridges and swellings. In interior view, hingement straight and ventral contact margin sinuous at middle. Hinge structure, character of marginal area, and adductor muscle-scar pattern same as for genus. In dorsal view, hinge line marked by shallow trough and posterior tooth of left valve more protruded than anterior tooth. Dorsal side of both valves nearly straight in outline and parallel each other.

Dimensions:—Holotype (complete carapace) length 0.54 mm., height 0.30 mm., thickness 0.27 mm.; paratype (complete carapace) length 0.52 mm., height 0.29 mm., thickness 0.27 mm.

Occurrence:—Type specimens were obtained from the Setana formation (Upper Pliocene) from the valley of Toshibetsu-gawa, about 800 m. W. of Omagari, Toshibetsu-mura, Setana-gun, Hokkaido (ASANO, 1950, Loc. C–4), where they are rare.

Remarks:—Outline of this species is different from "*Toulminia*" in detail, but circumscribing ridges and hinge structure suggest that this species retains some relationship to "*Toulminia*".

Pectocythere pseudoamphidonta HANAI, n. sp.

Pl. XI, figs. 4a–c; text-fig. 2.

Description: Carapace small and extremely thick-shelled, subovate in lateral outline, highest at anterior cardinal angle. Anterior

margin obliquely rounded, dorsal margin sinuous in anterior half and arched in posterior half, owing to strong projection of dorso-posterior ridge. Ventral margin nearly straight. Posterior cardinal angle distinct. Posterior margin truncated above and rounded below. Surface ornamented with scattered punctations which are outer surface openings of normal pore canals. An extremely blunt and thick ridge starts at anterior cadinal angle, runs down along anterior margin, and splits into about three fine parallel ridges. One of the fine ridges continues along ventral margin into posterior part of carapace. Anterior ridge does not quite reach anterior margin in lateral view in its upper half and projects over anterior margin in its lower half. Another extremely strong, blunt ridge starts posterior to middle of dorsal margin and terminates in mid-height of posterior area. A ventral thick, blunt, and more or less wing-like ridge swells in posteroventral area. Hinge structure, character of marginal area, and adductor musclescar pattern essentially the same as type species of genus. However, lower elements of anterior and posterior teeth of left valve well-developed so as to form large, round, knob-like projections, especially in anterior tooth. In anterior view, carapace appears to be trapezoidal owing to flat ventral area and thick, blunt, wing-like projections in posteroventral area. In the dorsal view, wing-like ventral projection prominent; hinge line straight and marked by a shallow trough. At anterior cardinal angle left valve overlaps right.

Text-figure 2. Internal view, left valve, of *Pectocythere pseudoamphidonta* HANAI, n. sp. (CA 2596)

Dimensions:—Holotype (a left valve) length 0.60 mm., height 0.35 mm.; paratype (a complete carapace) length 0.64 mm., height 0.37

mm., thickness 0.35 mm.

Occurrence:—All type specimens were obtained from the Setana formation (Upper Pliocene) from the valley of Toshibetsu-gawa, about 800 m. W. of Omagari, Toshibetsu-mura, Setana-gun, Hokkaido (ASANO, 1950, Loc. C-4), where they are rare.

Remarks:—The lapping of the left valve over the right at the anterior cardinal angle suggests relation of this species to *Arcacythere*. From *Pectocythere quadrangulata* this species differs in its large size, surface ornamentation, and the well developed anterior knob-like tooth of the left valve.

Genus "TOULMINIA" MUNSEY, 1953

1953 *Toulminia* MUNSEY, pp. 6, 7.

Type Species:—*Toulminia hyalokystis* MUNSEY, 1953

Diagnosis:—Small Pectocytherinae having compressed and subquadrangular carapace, with nearly straight posterior outline. Surface heavily ornamented. Marginal ridge nearly circumscribes periphery of carapace. In hingement of left valve, lower non-crenulate elements of anteromedian and posteromedian teeth are smaller than upper elements. Both upper and lower elements are usually fused together so as to make one knob-like projection. Radial pore canals straight and few.

Description:—Carapace small, moderately thick, compressed and subquadrangular in lateral outline. Anterior margin broadly and obliquely rounded and sometimes carrying short spine-like projections or a thin marginal lip. Dorsal and ventral margins nearly straight. Posterior margin short and straight making a right angle with ventral margin and bearing one to three blunt spines. Surface heavily ornamented with undulated ridges. A prominent ridge circumscribes periphery of carapace. Hinge of right valve consists of an anterior and posterior knob-like non-crenulate teeth and median finely crenulate groove between. Anterior and posterior terminations of median groove enlarged and deepened so as to form small sockets. Hinge of left valve consists of anterior and posterior sockets and median crenulate bar between. Anterior and posterior sockets open into the valve interior. Just posterior to anterior socket and just anterior to posterior socket, terminations of median

bar swell into low tooth-like projections. Teeth in left valve consist of upper elements which are swollen portions of the median bar. Below these are attached supplemental teeth which appear to brace the bar-teeth. In the genus "*Toulminia*" the upper element is about equal to or larger than the lower element. Sometimes the upper element develops extremely well and lower element becomes an attachment of the upper element. Marginal area broad anteriorly and posteroventrally. Vestibule well-developed, and deep anteroventrally, and poorly developed posteroventrally. Radial pore canals simple, short, and few. Normal pore canals few and scattered over carapace. Adductor muscle-scar pattern consists of posterior vertical row of four scars and at least one anterior scar. Sexual dimorphism observable. Convergence of ventral and dorsal margins less strong in female forms.

Remarks:—The change of the generic name will be made by MUNSEY. This is due to the preoccupation by the sponge genus *Toulminia* ZITTEL 1878 (HOWE, 1955)

"*Toulminia*" *japonica* HANAI, n. sp.

Pl. XI, figs. 1 a–e; text-figs. 3a, b, 4a, b.

Description:—Carapace thick and small, subrhomboidal in lateral outline, highest at anterior cardinal angle. Anterior margin obliquely rounded, with about three crenulations of marginal rim in its lower half. Dorsal margin slightly convex sloping moderately posteriorly, ventral margin nearly straight. Posterior outline also nearly straight, making almost a right angle with ventral margin, and having prominent spines, one at mid-height and another at posteroventral corner. Surface ornamented with undulated ridges. A prominent ridge circumscribes entire margin and is especially high along anterior and posterior margins where it deviates a little from the margin, owing to the strong development of the marginal rim. Inner bordering depression develops along anterior and posteroventral portion of marginal ridge; depression especially strong in posteroventral area. Undulated ridges inside of marginal ridge disposed more or less vertically. A prominent ridge starts at anteroventral portion of marginal ridge, runs posteriorly, then changes direction upward in posteroventral area, and terminates at

dorsal part of marginal ridge. Posteroventral contact margin narrowly rounded in side view. Character of hinge, marginal area and adductor muscle scars same as those of genus, but anterior and posterior teeth of left valve more distinct and more rounded than in type species. Lower non-crenulate element of anterior and posterior teeth moderately developed. Sexual dimorphism strong; in female form dorsal and ventral outlines not so much convergent as in male form. Two strong posterior spine-like projections in male and three weak projections in female. Moreover, female form has a characteristic posterodorsal projection.

Dimensions :—Holotype (male complete carapace) length 0.40 mm., height 0.21 mm., thickness 0.18 mm.; allotype (female complete carapace) length 0.44 mm., height 0.22 mm., thickness 0.18 mm.; paratype (male complete carapace) length 0.39 mm., height 0.21 mm., thickness 0.17 mm.; (male complete carapace) length 0.43 mm., height 0.22 mm., thickness 0.18 mm.

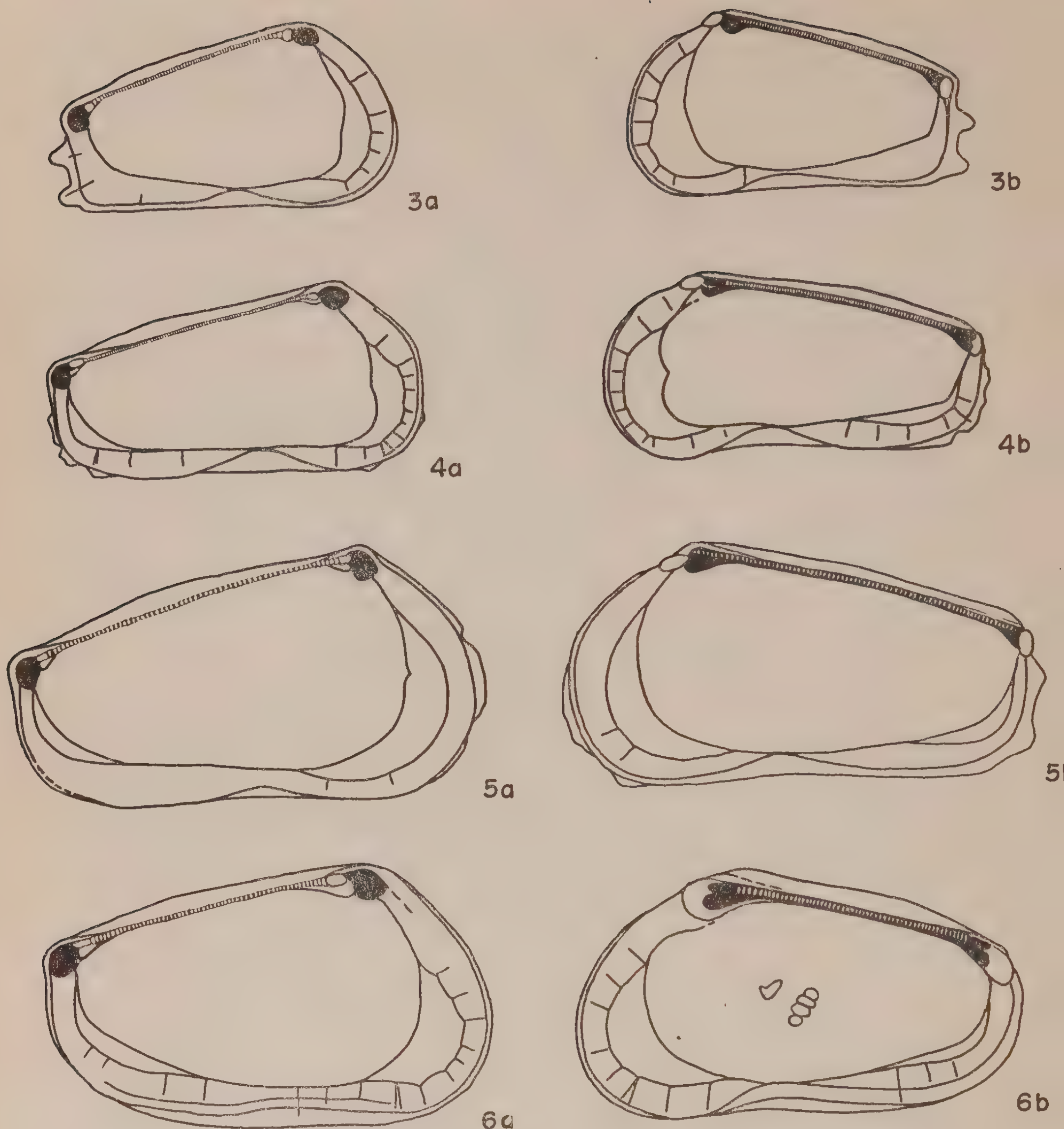
Occurrence :—All type specimens were collected from Recent beach sand from the shore behind an Imperial villa, Hayama-machi, Kanagawa Prefecture, where they are common.

Remarks :—"*Toulminia*" *hyalokystis* MUNSEY from Paleocene of the Gulf Coastal Plain of the United States is the only species of this genus which has been previously described. The Japanese Recent species shows striking resemblance to the American Paleocene species but in detail it is quite different, e. g. the surface ornamentation is not the same as that of the American species. Difference in hingement as mentioned above might suggest an evolutionary trend in the hingement of this group of Ostracoda.

"*Toulminia*" *hokkaidoana* HANAI, n. sp.

Pl. XI, figs. 2a, b; text-figs. 5a, b.

Description :—Lateral outline similar to "*Toulminia*" *japonica*, but larger and showing characteristic thin lip along anterior margin. Surface finely punctate except on blunt ridges. Prominent marginal ridge circumscribes entire periphery of carapace, being especially strong along anterior margin. Inner bordering depression deep along anterior margin and in posteroventral area. Two tubercles prominent in dorsocentral area. Very prominent ridge starts



Text-figures 3–6. Internal views of the pectocytherid carapaces.
a. left valve, b. right valve.
Figs. 3a, b, "*Toulminia*" *japonica* HANAI, n. sp. male (CA 2591)
Figs. 4a, b, "*Toulminia*" *japonica* HANAI, n. sp. female (CA 2590)
Figs. 5a, b, "*Toulminia*" *hokkaidoana* HANAI, n. sp. female (CA 2953)
Figs. 6a, b, *Pectocythere quadrangulata* HANAI, n. sp. (CA 2594)

at posterior tubercle, runs posteriorly a short distance, turns downward in posterodorsal area, and terminates in middle of posterior area. Other ridges less prominent. In side view, posteroventral contact margin narrowly rounded, ventral contact margin sinuous at middle. Hinge structure, characters of marginal area, and adductor muscle-scar pattern typical of genus.

Dimensions :—Holotype (female complete carapace) length 0.49 mm., height 0.28 mm., thickness 0.23 mm.

Occurrence :—The type specimen was obtained from the Setana formation (Upper Pliocene) in the valley of Toshibetsu-gawa, about 800 m. W. of Omagari, Toshibetsu-mura, Setana-gun, Hokkaido, (ASANO, 1950, Loc. C-4).

Remarks :—This species is closely related to "*Toulminia*" *japonica*, but the carapace of this species is larger and less sculptured than that of "*Toulminia*" *japonica*. The lower elements of the anterior and posterior teeth of the left valve of this species are not so well developed as those in "*Toulminia*" *japonica*.

Conclusions

Pentodont hingement, together with other shell structures, characterizes subfamily Pectocytherinae. This type of hingement consists, of upper and lower elements in the left valve. The upper element plays the main part in the hinge structure. The lower element develops only at the anterior and posterior terminations of the median bar in the left valve. In "*Toulminia*", the upper elements of anteromedian and posteromedian teeth are larger than the lower elements, and both upper and lower elements are fused together so as to make a knob-like projection. In *Pectocythere*, the upper elements are smaller than the lower, and both elements are well separated from each other.

Postscript :—The generic name *Toulminia* MUNSEY, 1953, has been preoccupied by the sponge genus *Toulminia* ZITTEL, 1878, as was pointed out by HOWE, 1955, in his Handbook of Ostracod Taxonomy. Thus, in this paper, the writer used the generic name *Toulminia* with quotation marks. After this manuscript was completed, however, VAN DEN BOLD (Micropaleontology, vol. 3, 1957, no. 1, p. 7) proposed a new name *Munseyella* for *Toulminia* MUNSEY, Therefore, "*Toulminia*" in this paper should read *Munseyella* VAN DEN BOLD, 1957.

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T. HANAI

Studies on the Ostracoda from Japan

II. Subfamily Pectocytherinae n. subfam.

Plate XI

Explanation of Plate XI

All figures ×88

Figs. 1a–e. "*Toulminia*" *japonica* Hanai, n. sp. 478

1a, right valve view of holotype (CA 2589).
1b, left valve view of holotype.
1c, right valve view of allotype (CA 2590).
1d, left valve view of allotype.
1e, dorsal view of paratype (CA 2592).

Figs. 2a, b. "*Toulminia*" *hokkaidoana* Hanai, n. sp. 479

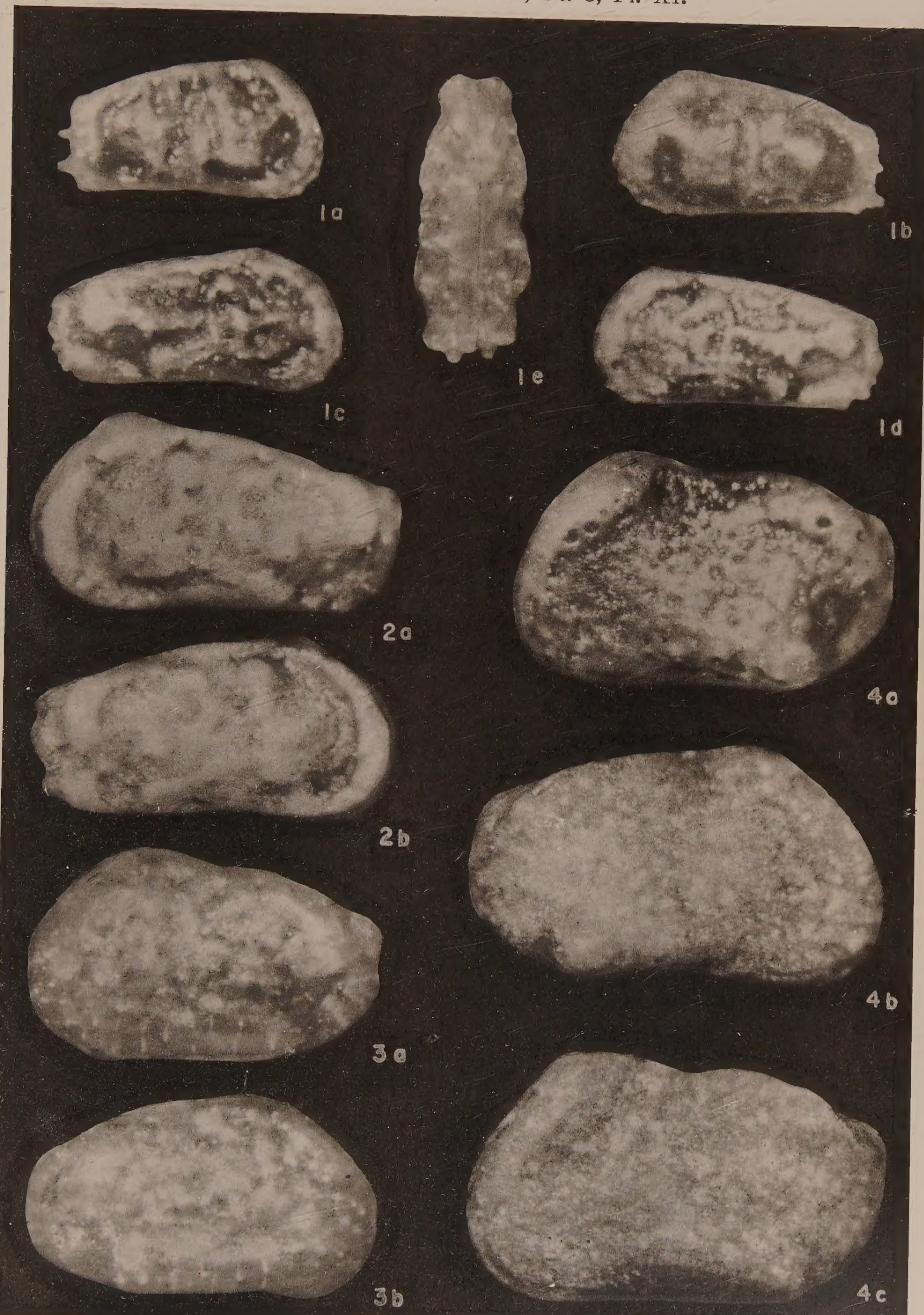
2a, left valve view of holotype (CA 2593).
2b, right valve view of holotype.

Figs. 3a, b. *Pectocythere quadrangulata* Hanai, n. sp. 474

3a, left valve view of holotype (CA 2594).
3b, right valve view of holotype.

Figs. 4a–c. *Pectocythere pseudoamphidonta* Hanai, n. sp. 475

4a, left valve view of holotype (CA 2596).
4b, right valve view of paratype (CA 2597).
4c, left valve view of paratype (CA 2597).


1a
1e
1b
1c
1d
2a
4a
2b
4b
3a
3b
4c

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Price in Tokyo: Yen 320 for this Part.

昭和三十二年十二月五日 印刷
昭和三十二年十二月十日 発行

編纂兼発行者 東京大学

東京都港区芝浦一丁目一番地
印刷者 富田元

東京都港区芝浦一丁目一番地
印刷所 ヘラルド社

東京都中央区日本橋通二丁目六番地
売捌所 丸善株式会社